APPLICATION OF IT IN NATURAL DISASTER RISK MANAGEMENT: CASE STUDY OF BANDUNG EARTHQUAKE MITIGATION PROJECT

KRISHNA S. PRIBADI, H. R. PERTIWI AND I SJABRI
Institut Teknologi Bandung
Bandung, Indonesia

ABSTRACT

Two applications of Information Technology (IT) found a place in the Bandung Urban Earthquake Mitigation Project, within the framework of the Asian Urban Disaster Management Project, i.e. the use of GIS in risk assessment and mapping and the use of Internet facilities (Homepage and FTP) in disseminating project results through a collaborative network

The role of the GIS in the risk assessment process is in the management of all spatial information related to the hazard, exposure and the vulnerability of the city. Supported by GIS, risk analysis, by combining various hazard, exposure and vulnerability parameters at the postal code level of the city sub-districts, called kecamatan, produces risk maps of the city The risk map is then fed in for the review of the city's spatial development and land use planning. The map will also be used for the purpose of raising awareness among various actors in the city development process, including the private sector and the community. Mitigation strategy drawn from the produced hazard and vulnerability maps, provides guidance for various mitigation activities such as the reform of the local building regulation, prioritization of high risk area, training, etc.

A networking scheme of national institutions, organizations and individuals advocate to mitigating natural disaster is also being set up within the project. The role of the IT in this activity is in providing a media of communication and dissemination of information and lesson-learned to those who are involved and/or interested in the project and the experience. A home page will be set up for the project, which can be accessed by the internal and external network participants and interested parties. Members of the networks might include high risk municipalities, national organizations and agencies dealing with disasters and emergency response, university disaster research centers, professionals and practitioners, NGOs and interested individuals.

1. INTRODUCTION

In natural hazard exposed areas, pre-, during- and post-disaster mitigation processes depend largely on the interaction of the main actors: the community, the media, the experts and the public authority. Mauro

(1993) suggested an interactive model in which the information communication holds a central role in the interaction of the actors. The development of information technology in the last two decades provides a wide support for the natural disaster management and mitigation activities. The advances in computing systems, software and communication technology have brought new development in the disaster mitigation approaches, especially in risk management and information support. The use of new IT hardware and systems such as CD-ROM and Internet has been implemented in communicating information for natural disaster risk management purposes, such as shown in Cody and Tao (1996) and Frohmberg (1996). A few examples of the development of GIS based risk management and risk assessment systems are presented in Sigbjornsson and Baldvinsson (1996). Koike et al. (1996) and King and Kiremidjian (1997).

In urban earthquake mitigation, risk management depends largely on the result of hazard analysis and vulnerability assessment of the area, and on the effectiveness of communicating the result to various parties involved in the urban development, the public authorities, the private sector and the community. When available, information technology could enhance the above processes and improving its effectiveness. This paper presents a case study on the application of GIS and the use of information technology facility for urban earthquake disaster mitigation activities.

2. PROJECT DESCRIPTION

2.1 Background

Bandung, the capital city of West Java is the third largest Indonesian city after Jakarta and Surabaya with about 2 million population in the municipality and about 4 million inhabitant in the surrounding communities which is known as The Greater Bandung (Bandung Raya). It is expected that in the year 2010 the population of Greater Bandung, or the Metropolitan of Bandung, will be approximately 7 million. Part of the area is located in the prehistoric lake bed of Bandung plateau in West Java, surrounded by mountains and active volcanoes, which is called the "Bandung Basin" Bandung is highly prone to various type of natural disaster such as earthquake, volcanic eruption, floods, landslides as well as fire hazards and typhoons. Seismically, Bandung is located in Zone III of seismic map zoning of Indonesia, representing middle range of seismic hazard. Although there are no historical records of damaging earthquakes in the Greater Bandung area during the last century, active faults found around the area, as well as the Indo-Australian subduction zone laying in the ocean bed, south of West Java, show that Bandung has the potential to experience damaging earthquake.

Due to its population density and fast uncontrolled urban growth, as well as its soil condition, characterized by the deep alluvium formation from the ancient lake bed sediment which covered a large part of the Bandung plateau (particularly in the southern part), the city is considered vulnerable to ground shaking. The Indonesian Urban Disaster Mitigation Project (IUDMP), within the framework of the Asian Urban Disaster Mitigation

Program (AUDMP) in collaboration with the Asian Disaster Preparedness Center (ADPC), which consists of a demonstration project, policy input, networking and training components, is being conducted to address to this situation.

2.2 Project Objective

The demonstration project component objective is to show that a successful earthquake mitigation program can be implemented in the development process of the city, based on the assessment of the seismic risk of the area, by carrying out the following works:

- identify, analyze and map seismic hazard in the study area, related to seismic source zone, peak ground acceleration and its secondary effects such as liquefaction, landslides, fires and flooding,
- identify the vulnerability of the city towards an earthquake related to the physical infrastructures condition, exposure of the city, social and economic condition, and institutional preparedness,
- identify and formulate earthquake feasible mitigation strategies for the area, and
- disseminate the lesson learned from this demonstration project through a collaborative network of disaster mitigation advocates in various agencies, municipalities, private sector and NGOs, on a national and regional level.

3. RISK ASSESSMENT AND GIS

3.1 Objective of risk assessment

The objective of risk assessment in this project is to produce city risk maps showing the risk level of various part of the city toward seismic disaster.

The risk maps are then fed in for the review of the city's spatial development and land use planning. They can also be used for the purpose of raising awareness among various actors in the city's development process, including the private sector and the community. Mitigation strategy is also drawn from the produced hazard and vulnerability maps, such as the reform of the local building regulation, mitigation activities in prioritized area (the area with the highest risk), etc.

3.2 Assessment Procedure

Basically there are three types of risk assessment methods (Davidson, 1996; Davidson, 1997). The first method is based on loss estimation models, which require an extensive detailed technical information, and producing information on expected structural damage and economic loss in absolute (monetary or others) terms. The second is based on earthquake damage scenarios and this method needs also extensive detailed qualitative and quantitative information, which produces qualitative description of expected series of events following an earthquake. Both methods can be combined to produce a more comprehensive insight of the associated risk level of a damaging earthquake in an urban area. The third method proposed by Davidson (1996), (1997), uses simple, measurable, scalar indicators of five main factors (hazard, exposure, vulnerability, external context and emergency response and recovery planning of each city) to produce composite index of risk (earthquake disaster risk index - EDRI), as relative measures of risk level of cities. The unit of study of this method is usually greater metropolitan areas.

The method used in this project is a modification of the third method. As the EDRI method proposed by Davidson is for comparing EDRI values of greater metropolitan areas of the world, it is not suitable for city level risk assessment. The modification consists of the use of relevant indicators applicable at smaller, adjacent sub-district areas of the city, to calculate risk indicators in the various part of the city. The involved factors are the hazard, the exposure and the vulnerability of each study unit, and the indicators are adjusted to accommodate the restricted availability of data in the city.

3.3 The role of GIS in the process

The role of the GIS in the risk assessment process is in the management of all spatial information related to the hazard, exposure and the vulnerability of the city. Information on topographical and geological conditions as well as physical infrastructures, lifelines, social facilities such as education, health and religious facilities, social and demographic indicators are fed into the GIS database. The result of seismic hazard analysis in the form of microzoning of peak ground acceleration, soft soils, liquefaction and landslide potentials are collected in the GIS. The resolution of the spatial information is at the postal code level of the city sub-districts, which is called kecamatan (population from 30,000 to 100,000 with a mean of 69,000). Using a predefined relative risk indicator by combining various hazard, exposure and vulnerability parameters of each kecamatan as the basic unit of analysis, a risk map of the city is prepared, on a kecamatan level accuracy.

The GIS platform for the analysis is the ARC/INFO and ARC/VIEW software, which consists of cartographic database combined with various attributes, through common identifier. Various data manipulation facilities are available which facilitate the processing of various thematic maps in different layers. Input data is obtained by digitizing various information available on maps as well as numerical data from various municipal offices.

In the future, supported by the developed project database, the geographical information system could be used for monitoring of the urban development activities in the framework of an integrated urban disaster mitigation process.

3.4 Sample results of GIS maps

Figures 1 to 10 (included at end this paper) present some samples of the GIS maps, showing the hazard distribution in Bandung area, and some vulnerability and exposure indicators, which combined with the former produce the risk map of the city, indicating the relative seismic risk of each kecamatan.

The map can be used for formulating long term mitigation strategy which can be implemented by the public authorities (building control office, land use planning section, civil defence, police and army, etc.). A prioritized area based on the high risk kecamatan can be selected for further mitigation activities, such as the retrofitting of special buildings and lifelines.

4. NETWORKING AND INFORMATION TECHNOLOGY

4.1 Network objective

In enhancing the sustainability of the project idealistic goal and replicating the successful hazard mitigation practices from the demonstration project throughout the region, the information dissemination and networking play an important part in the project. A national network on urban disaster management and mitigation is being established by the project. The network is named **KOMPAK**, an abbreviation for **K**erjasama **O**rganisasi **M**itigasi bencana **P**ada daerah per**K**otaan (Collaboration of Urban Disaster Mitigation Organization), which also means solid (community) in Bahasa Indonesia, will put various organizations and agencies, including NGOs, advocate to disaster mitigation, in close collaboration by exchange of information and organizing joint activities.

It is hoped that the network would enhance the ability of the existing National Disaster Coordinating Committees (BAKORNAS PB and SATLAK PB) in improving the national preparedness as part of national disaster management system.

The network would be accessible to various organizations, agencies and municipalities and may help build a platform of a forum for exchanging information and experiences on urban disaster management practices. The broader aim of KOMPAK is to create a forum for concerted national disaster mitigation organization, research, training and practical action in the seismic hazard and seismic vulnerability assessment of urban area in order to identify the basis for common understanding and implementation of sustainable urban development.

The key objectives of KOMPAK network program are as follows:

- To help build public and private networks as a forum for exchanging information and experiences on urban disaster management
- To propose and develop a national baseline data consisting of detailed, medium and long term information on potential exposure toward earthquake on urban area

- To establish a reliable National Network that could disseminate the mitigation information efficiently among the actors (participants)

4.2 Network structure and IT support

KOMPAK network program basically consists of three main workspaces for communications, i.e. Intranet, Extranet and Internet, as shown in Figure 11.

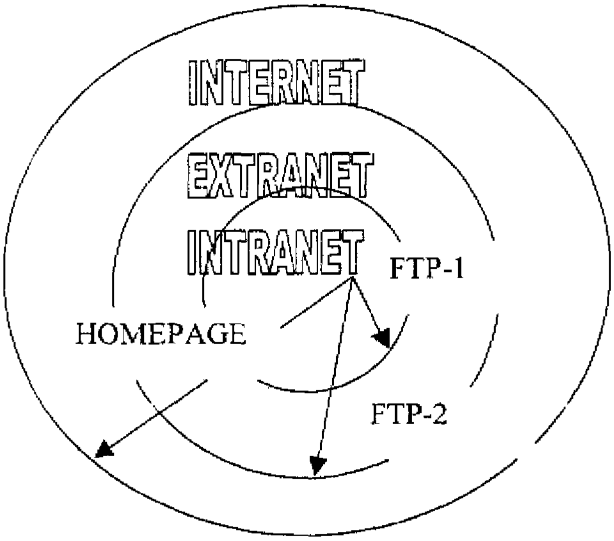

Figure 11. Communication and workspaces of KOMPAK Network

- **INTRANET**

The Intranet, an internal network, will be a forum set up in the initial stages of the project to facilitate immediate communication between the project team and participants. The Intranet will be a discussion forum and will also hold documents in the process of productions of the project result. The project result documents will be used as the basis to develop a national baseline data consisting of detailed, medium and long term information on potential exposure toward earthquake on urban area base. It will thus be a means of collaborative working. In the Intranet, access will be limited to the project team and participants who will be able to air embryonic or partially formed ideas, to disseminate and discuss the project result within closed community. The activities in this network can be accommodated by the use of FTP (File Transfer Protocol) network called FTP-1 Network. The FTP-1 network has the maximum capacity within the whole KOMPAK Network Program, where each project team and participants have equal privilege to access (read and modify) data in the network.

- **EXTRANET**

The Extranet, an external network, will be a forum for actors' representatives, such as the project stakeholders, the ADPC, selected national institutions, replicating cities, selected non-government organization, individual experts and/or other Asian Demonstration Projects. The actors will also use the Extranet to test the products of the project in conjunction with the IUDMP research team.

In the Extranet, access will be limited to the actor's representatives who will be able to air ideas, to disseminate and discuss findings within selected community. The activities in this network can be accommodated by the use of FTP (File Transfer Protocol) network called FTP-2 Network. In this network,all actors have the privilege to access (read only) the data, but data can only be modified by selected actors.

- **INTERNET**

The Internet is a forum to be used to disseminate the information and action plan developed by the project in the Intranet to all interested parties. The Internet will only accommodate and publish the product of the project or other findings when it is fully developed in the Intranet and tested in the Extranet. Besides, the Internet will also disseminate any other information related to the Urban Disaster Mitigation Project.

In the short term, Internet can be accessed free of charge by all interested parties. All activities in this network are accommodated by a Homepage set up by the project. To make the project's goal sustainable, in the long term other media such as hard publication will support the Internet, and it can be accessed by all interested parties with a minimum charge for compensation of production, operation and maintenance expenses.

5. CONCLUSION

An application of GIS in the risk assessment of urban seismic disaster has been presented. The method is based on a composite risk index developed by modifying a similar system for greater metropolitan cities. Many works still have to be carried out to refine the scientific basis of the method and to improve the replicability of the process within the constraint of availability of data in the Indonesian cities. A networking scheme has also been presented, with the objective of providing a forum of information exchange in urban mitigation practices among various urban development planning actors. The networking scheme is supported by various information technology services.

REFERENCES

Cody, P.A. and D.S. Tao (1996): *Comprehensive CD-ROM Index in Earthquake Engineering,* in Sociedad Mexicana de Ingenieria Sismica A.C., Proceedings of The Eleventh World Conference on Earthquake Engineering, Acapulco, Mexico, June.

Davidson, R. (1996): *Development of A Multidisciplinary Urban Disaster Risk Index*, in Sociedad Mexicana de Ingenieria Sismica A.C.:

Proceedings of The Eleventh World Conference on Earthquake Engineering, Acapulco, Mexico, June.

Davidson, R. (1997): *An Urban Earthquake Disaster Risk Index*, Report No.121, The John A. Blume Earthquake Engineering Center, June, Stanford, California.

Frohmberg, K.A. (1996): *Earthquake Information Sources on the Internet*, in Sociedad Mexicana de Ingenieria Sismica A.C., Proceedings of The Eleventh World Conference on Earthquake Engineering, Acapulco, Mexico, June.

King, S.A., and A.S. Kiremidjian (1997): *Regional seismic Hazard and Risk Analysis Through Geographic Information Systems*, Report No.111, The John A. Blume Earthquake Engineering Center, June, Stanford, California.

Koike, T., T. Imai and T. Kaneko (1996): *Liquefaction Hazard Mapping of Regional Area by Using GIS*, in Sociedad Mexicana de Ingenieria Sismica A.C.: Proceedings of The Eleventh World Conference on Earthquake Engineering, Acapulco, Mexico, June.

Mauro, A. (1993): Stop Disasters: *The Newsletter of the UN International Decade for Natural Disaster Reduction*, in Horlick-Jones, Amendola and Casale, Eds, Proceedings of he International Conference on Natural Risk and Civil Protection organized by CEC, Belgirate, Italy, October.

Sigbjornsson, R., and G.I. Baldvinsson (1996): *The Mapping of Seismic Hazzard Using Stochastic Simulation and Geographic Information System*, in Sociedad Mexicana de Ingenieria Sismica A.C., Proceedings of The Eleventh World Conference on Earthquake Engineering, Acapulco, Mexico, June.

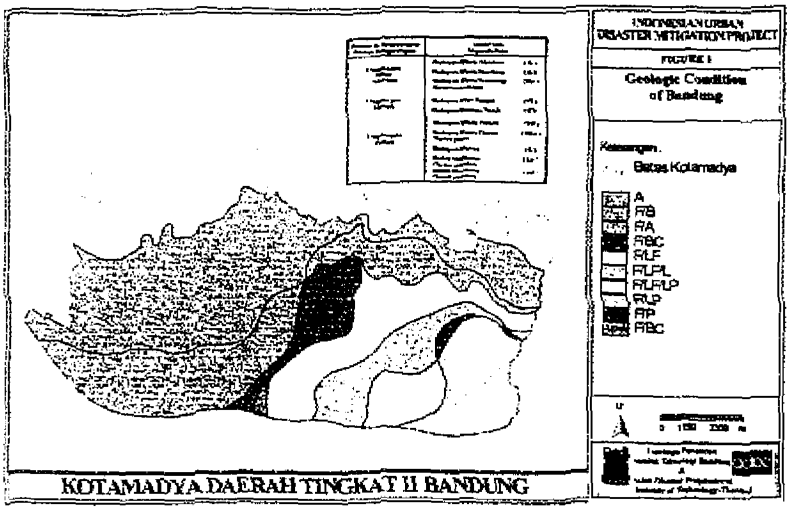

Figure 1. Geologic map of Bandung area
(refer to page 362 for color print)

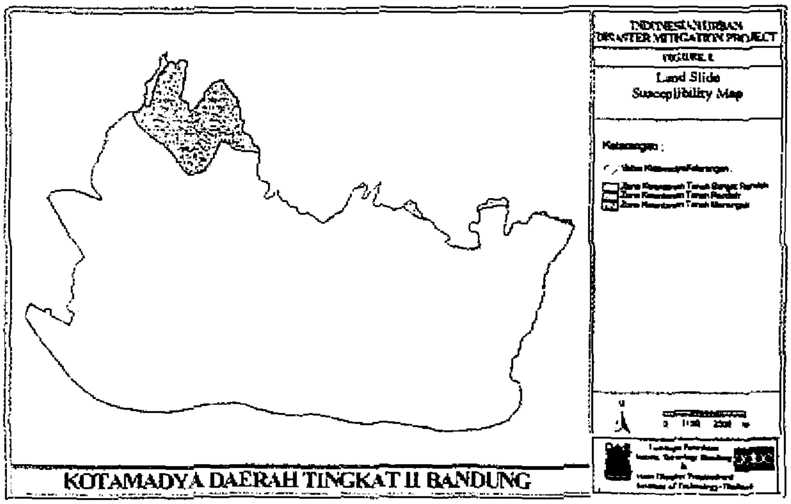

Figure 2. Landslide hazard map
(refer to page 363 for color print)

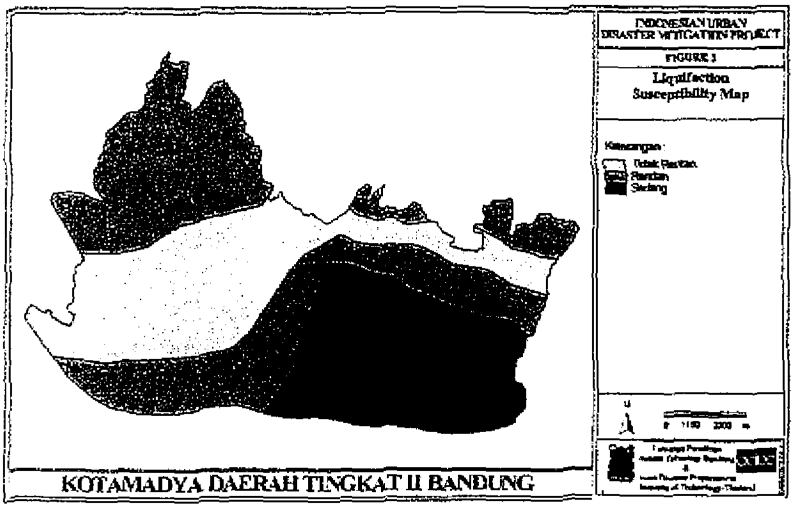

Figure 3. Liquefaction susceptibility map
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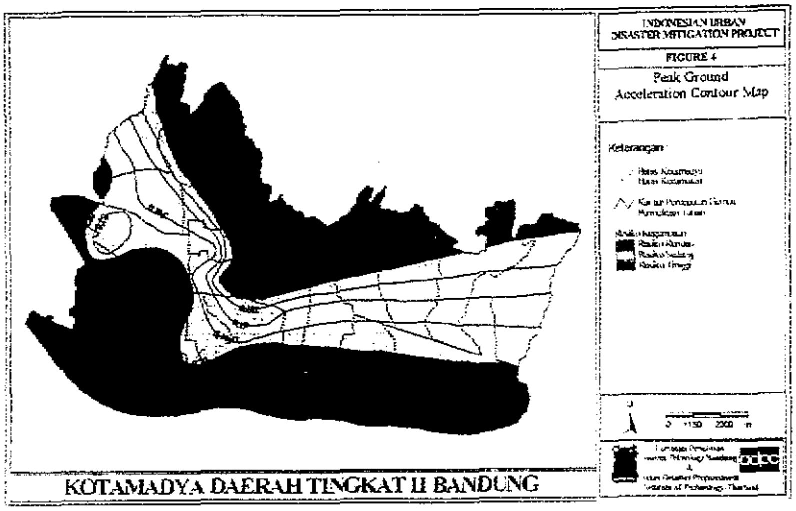

Figure 4. Peak ground acceleration contour map
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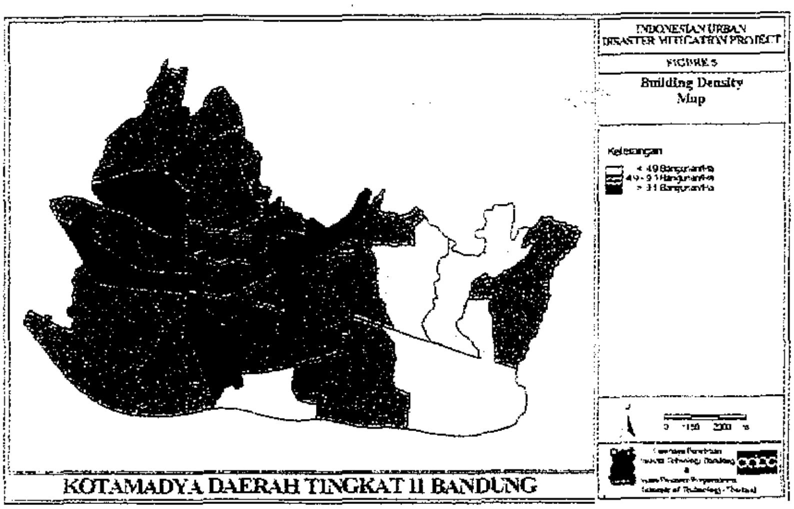

Figure 5. Building density map
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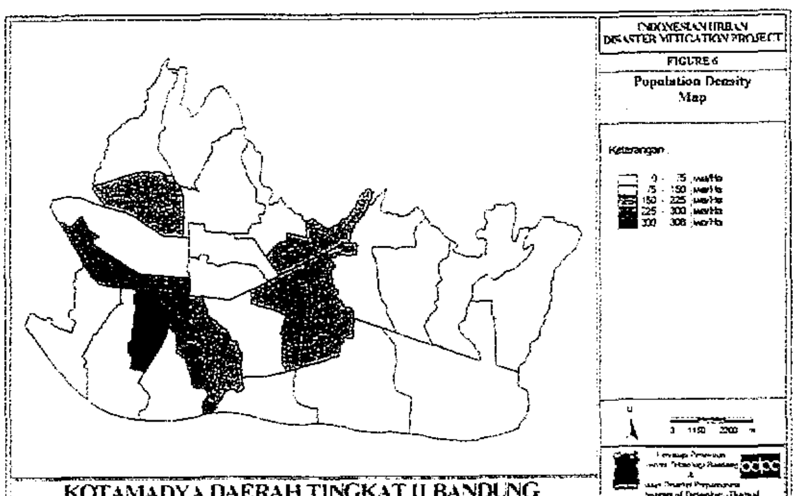

Figure 6. Population density map
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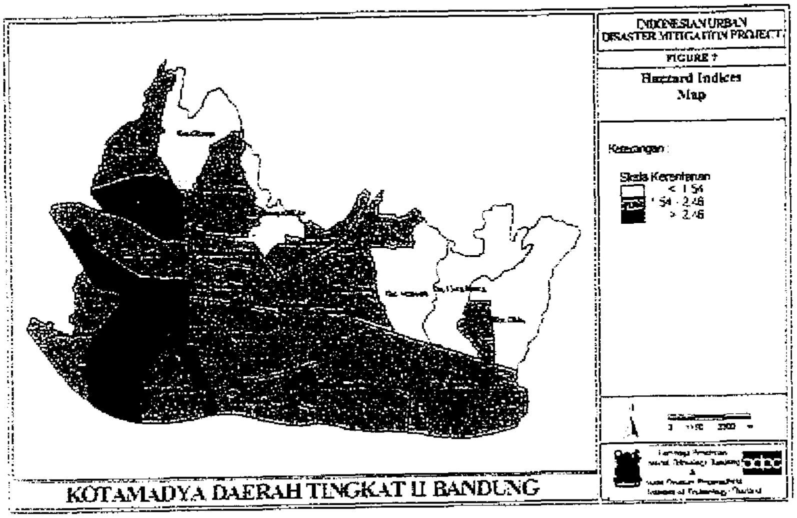

Figure 7. Hazard indices map
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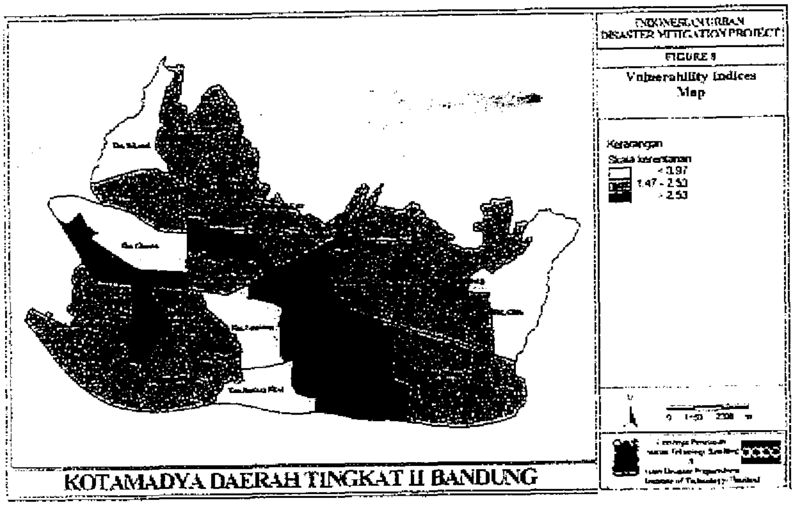

Figure 8. Vulnerability indices map
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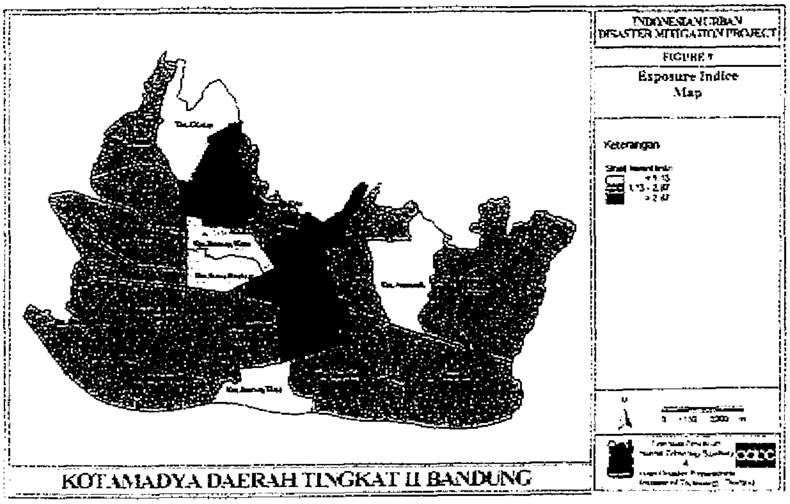

Figure 9. Exposure indices map
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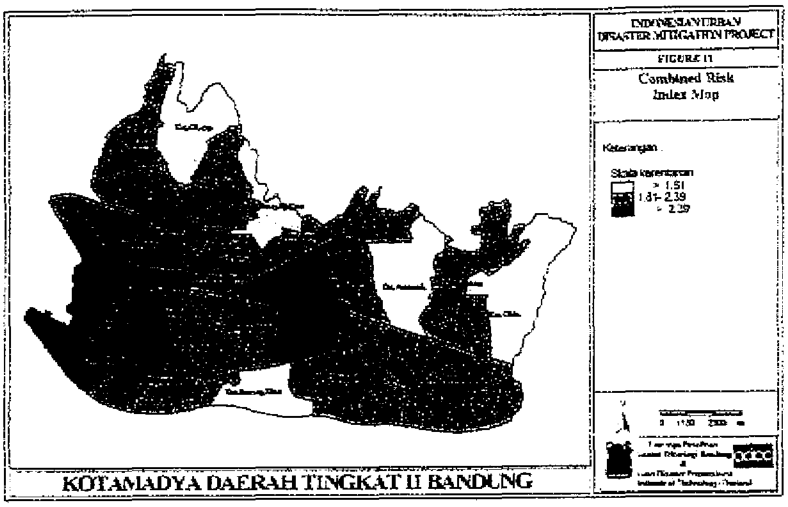

Figure 10. Combined risk index map
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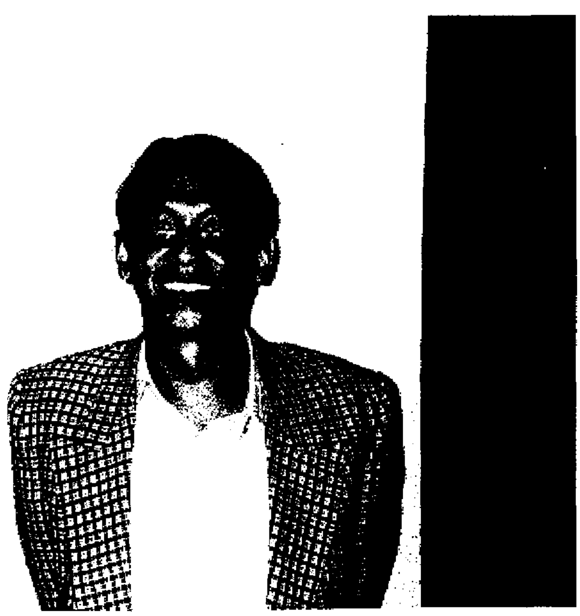

Dr. Krishna S. Pribadi