Chapter 5 Project Evaluation

5.1 Overall Goals and Project Purposes

A systematic and objective assessment was made in order to provide highly reliable and useful information to be utilized in the decision-making processes of both the donor and recipient countries. The project evaluation is summed up as shown below.

(1) Project purposes

- Establishing the foundation of 1:50,000-scale national base maps for GIS
- Producing hazard maps in relation to earthquakes, volcanoes, landslides, and floods
- Transferring the technologies and know-how related to these hazards

(2) Overall goals

- Allowing the counterpart organizations to further develop the products of the project for themselves
- Commercializing the technologies to pave the way for self-supporting activities
- Sharing databases to cut budgets of the national government and effectively use data for the National Development Plan
- Providing and sharing data with assistance programs, NGOs, etc. to build mutually supportive relationships
- Consequently bringing about stability to the people's livelihood, enhancement of social infrastructures, and improvement of their living standard
- Also promoting people's understanding of disaster prevention

5.2 Five-item evaluation

The five-item evaluation assesses an entire project from a comprehensive perspective with focuses on project purposes and overall goals.

(1) Relevance
(2) Effectiveness
(3) Efficiency
(4) Impact
(5) Sustainability

This evaluation method verifies whether the project must be implemented, i.e., "validity of the project," and what kind of effects the project had on beneficiaries, whether the project was effective in terms of effective use of resources, whether the implementation of the project has long-term indirect or ripple effects, and whether there are lasting effects once the project was completed.

5.3 Evaluation results

① **Relevance**

The Government of Guatemala facing many tasks including securing of resettlement areas for refugees in the vast Peace Zone and redevelopment of infrastructures, defined the "disaster prevention" as an urgent task in the process of promoting national land development. The hazard maps must be developed urgently in order to establish disaster prevention plans while the national base maps containing up-to-date information are required for the development plans. The Government of Guatemala declared the policy of "establishing base maps for GIS" which is predicated on the update and extensive use of the base maps. The government also established the Inter-ministry Liaison Conference (hereinafter "SNIG") and is thus preparing for setting up organizations for sharing of information and utilization of GIS.

The Project is aimed mainly at the development of 1:50,000-scale national base maps for GIS as well as hazard maps in relation to earthquakes, volcanoes, landslides, and floods and transfer of related technologies and know-how, all of which are consistent with the needs of the counterpart organizations and the Government of Guatemala and people. In conclusion, the Project has high relevance.

② **Effectiveness**

All of the following three project purposes were attained as initially planned:

- Establishing the foundation of 1:50,000-scale national base maps for GIS
- Producing hazard maps in relation to earthquakes, volcanoes, landslides, and floods
- Transferring the technologies and know-how related to these hazards

The products of the Study, 1:50,000-scale national base maps for GIS and hazard maps, were completed with accuracy. Furthermore, the technology transfer particularly contributed to the accomplishment of the project purposes. The technology transfer was provided in relation to digital mapping, GIS, and creation of printed map data. The training was attended by a total of 88 participants from both the counterpart organizations, who became capable of carrying out continued activities on their own as beneficiaries. In conclusion, the Project achieved significant effects on propagation and continuation of technologies.

③ **Efficiency**

The following lists the input.

- Japan: 15 members of the Study Team

  Equipment for study (for IGN): digital plotter, film scanners, printers, digital

compilator, plotters, and sets of hardware and software for GIS
(for INSIVUMEH): Sets of hardware, software, and plotters for GIS
(common use): GPSs and PCs for base line analysis

- Guatemala: About 100 persons from counterparts (collaboration), 88 persons from counterparts (technology transfer), a total of two project offices (in IGN and INSIVUMEH)

The input from Japan and Guatemala was necessary and sufficient in terms of types, period, quality, and quantity to accomplish results.

Normally, we can judge whether the input costs are adequate by comparing them with other similar projects. However, there is no other project that can be compared with the Study because the latter is special and consists of two segments, production of base maps/GIS databases and production of hazard maps. The relevance of the Project is beyond doubt if we judge it based on the values that have been obtained from the past projects.

④ Impact

The following six overall goals cannot be easily assessed in terms of the effects of the project because, at the moment, no specific evaluation indexes have been established. We hope that follow-up research will be conducted on them in the future.

- Allowing the counterpart organizations to further develop the products of the project for themselves
- Commercializing the technologies to pave the way for self-supporting activities
- Sharing databases to cut budgets of the national government and effectively use data for the National Development Plan
- Providing and sharing data with assistance programs, NGOs, etc. to build mutually supportive relationships
- Consequently bringing about stability in people's livelihood, enhancement of social infrastructures, and improvement of their living standard
- Also promoting people's understanding of disaster prevention

However, some specific activities are being observed concerning "positive impacts" which were not expected initially.

The ripple effects are significant. For example, IGN started digitizing 1:50,000-scale national base maps for GIS for an area not covered in the Study on its own (continued activities using the equipment used for the Study) and promoting supply of data to the project to combat Chagas' disease implemented by JICA and to SNIG.

⑤ **Sustainability**

As described above, IGN is carrying out continued activities on its own to digitize 1:50,000-scale national base maps for GIS for an area not covered in the Study using the equipment used for the Study. Specifically, IGN secured a budget for new aerial photographic surveying on the northeastern area, next to the Study Area, and already completed shooting photographs on 10,000km^2, clearly demonstrating the enthusiasm of this organization.

From these facts, we are confident that the sustainability has reached a fully satisfying level.

Chapter 6 Conclusion and Recommendations

6.1 Conclusion

The Study has accomplished the initial purposes although it is a complex and special project consisting of two segments; establishment of national base maps/GIS databases and hazard maps.

We understand that this result was achieved due to the understanding of the Guatemalan government about the method of implementing the project, which focused not only on project products but also on technology transfer, and thanks to the enthusiasm and efforts made by both the Japanese and Guatemalan staff members.

In the final year, we held two seminars, one of which was attended by 18 guests related to GIS and disaster prevention in the Central America and Caribbean areas. We are confident that the seminar, thus disseminating information on the circumstances of the Study as well as what the products are and how they can be effectively utilized, will serve as a signpost for the future disaster prevention in the Central America and Caribbean areas including Guatemala.

6.2 Future development of transferred technologies

6.2.1 Digital plotting/compilation technologies

The equipment to conduct the digital photogrammetric survey was introduced to IGN and the technology transfer for producing the products using the equipment was furnished three times. For effective use of these equipment and technology, three points that the staff of Photogrammetry Division should cope with on their own initiative are:

1) Training of engineers
2) Increase of production
3) Higher production efficiency

The practical methods of coping with these issues are recommended as follows:

(1) Training of engineers

The "VirtuoZo" that was introduced in this project will be operated only by a limited number of operators because one set of equipment is available. So it is difficult to train many engineers. In the digital photogrammetry, it is very important to acquire not only the knowledge on photogrammetry but also on information processing. It will take very much time to train engineers for both types of knowledge. To solve this problem, it is recommended that the staff members acquire a part of and take partial charge of the technology.

The workers engaged in analog plotting are the specialists in photogrammetry and young engineers are relatively familiar with PC operation. For instance, the vector data acquisition process can be undertaken by plotting engineers and the orthophoto image production process by young engineers familiar with PC operation. The work is shared by both types of engineers, but if they are grouped, both types of engineers can complement their knowledge mutually, thereby ensuring their deepened understanding of the technology.

It is desirable that the engineers engaged in compilation undertake the compilation of plotted data. Unlike the analog method, however, the data subject to compilation is thoroughly reflected on the final product in mapping based on digital data, eliminating the drafting process that had been so far. Therefore, the engineers in charge of compilation need the knowledge on cartography and printed maps. Sometimes, they are required to operate Illustrator. Individual engineers have to acquire not only the knowledge on compilation but also on such peripheral technology as needed.

(2) Increase of production

If a large volume of data should be acquired in the future, one set of VirtuoZo PC may result in a situation that it cannot deal with such large volume of data. The work in shifts or the introduction of a new digital photogrammetry system can be considered as a solution, but it is recommended to make the effective use of the existing analog plotter (Photo 6.2-1) as a realistic solution.

In practice, the acquisition of 3D vector data (Figure 6.2-1) has to be performed in connecting an encoder to the analog plotter. In addition of increase of production, the advantages of using the analog plotter are that two times of digitization can be avoided in comparison with digitization of analog maps, and that 3D data with high utility for designing is available. Another advantage is that the engineers of analog plotter can be shifted smoothly to the work with the digital photogrammetry system. The shift from the analog plotter to the digital photogrammetry system will be drastic, but the use of the analog plotter with encoder will bring the same effect as an intermediate analyzing plotter (Photo 6.2-2) and ensure the engineers to empirically recognize the significance of categorizing planimetric features into layers and acquiring them as data.

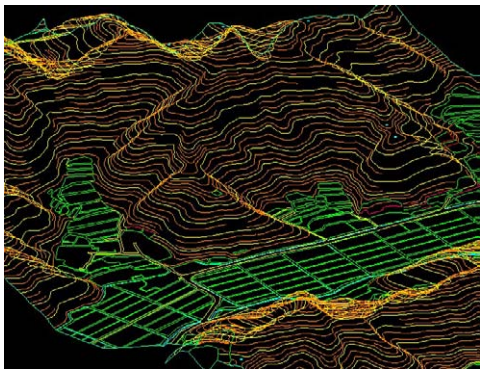

Figure 6.2-1 3D vector data

Photo 6.2-1 Analog plotter installed in Photogrammetry Division

Photo 6.2-2 Analyzing plotter

(3) Higher production efficiency

For map production with high efficiency, it is most important to conduct the process control in a complete manner. This is the same case in the digital process as well as in the analog process. However, the digital photogrammetry is a work that the staff members have not experienced, so that they have to determine the efficiency in each step. They have to calculate the efficiency of any small work step and accumulate the performance data.

For higher work efficiency, the work should not be promoted within Photogrammetry Division. The work to use the data acquired in photogrammetry for GIS will apparently increase in the future. In such case, the work process should not be completed within Photogrammetry Division, but it is desirable to search for any method with the highest efficiency and plan the work processes in considering the future processes. In digitalizing the photogrammetry work, the barriers among other divisions will be gradually lower. Especially, there are many technologies that are overlapping with Cartography Division. It is necessary to increase the opportunity of discussions between both Divisions in order to reduce the discrepancies between data specifications required by Cartography Division and those provided by Photogrammetry Division. It is the most desirable way that the staff members of both Divisions are exchanged even for a certain period.

6.2.2 Database/GIS technologies

(1) Software compatibility problem and fund raising for costs for version-up

While this project is implemented, the version of ARCINFO (ESRI Corp.) was upgraded three times. The latest version improved the Coverage that had been the conventional leading data format and limited it to the support of the new type of data format called GeoDatabase with no downward compatibility. The policy of ESRI was to convert the data from the conventional Coverage into GeoDatabase. This means that the latest version of ArcGIS could not edit the Coverage, but can only allow browsing or converting the data into a new type of data. The change of policy was not foreseeable when starting the project and it imposed a heavy burden on the long-term users of the software.

IGN has a license for the old version of ARCINFO Workstation 4 as well as the license granted by the JICA team, and they are using these licenses for the current services such as data creation and editing. Therefore, it is not realistic to use the license granted by JICA team for ArcGIS, if the effective use of the property that IGN has developed so far is taken into account.

However, the external pressure on the version upgrading will increase in a few years and it is evident that IGN must change the data format into the new one sooner or later. It is thus necessary to access upgrading cost of the existing application under the license and data conversion, and to plan the future work. It is also necessary to make the profit profile to raise the fund for the required cost from the equipment, technology, products and others provided in this project.

(2) Problems and recommendations for GIS technology transfer

As described above, not only the software operation but also a wide range of knowledge on GIS is required for the personnel engaged in GIS. As seen from the character and conduct of IGN engineers, they were simply studying the software operation, but their understanding of the conceptual items was insufficient. It seems that they could process the data in the same environment, but probably would fail in a different environment. The organization of the personnel in charge of processing in practice and that of other personnel are not planned in the proper manner and many engineers seem to receive training because they just have an opportunity. In this situation, the technology that they can acquire would not develop further and the opportunity of the engineers with a necessity to be trained for the technology may be lost. It is strongly recommended that the responsibility of each engineer to participate in technology transfer training be defined to enhance his motivation in the technology transfer.

6.2.3 Digital Printing technologies

The present problems and solutions concerning the digital printing work and the recommendations for the future development will be described below.

(1) Film outputs

In general, the files created on Illustrator in the digital printing process are outputted as printing film outputs through an image setter, from which reproduction blocks were made and put on a printing press machine. In short, if the reproduction film outputs were not applied to press, it would be meaningless to create maps on Illustrator, apart from the proofreading inspection on the color prints outputted from a printer.

The Printing Division of IGN possesses no image setter and uses the conventional analog printing method at present. If they purchase an image setter, this problem would be solved, but it is difficult due to the present high cost. (For reference: The costs required for an image setter used by a middle-size printing company in Japan are: 8 million yen or more for image

setter; 20 million yen or more if a higher precision of color reproduction blocks is required; the running cost consists of the material expenses of 300,000 yen or more per month and the maintenance cost of about 200,000 yen per year, and the personnel cost for dedicated operators. Since this machine is specified for A3 outputs, the cost of a machine for map reproduction blocks will be much higher.)

Therefore, the film outputs must be subcontracted to a company. At present, one company in the private sector possesses an image setter in Guatemala, to which IGN had requested for quotation, but the quoted price had not meet their budget. So they had given up this plan. No other source of an image setter has been grasped in Guatemala so far.

In the digital printing environment, it is unnecessary to bring in a large volume of block copy manuscripts attained, but the delivery of manuscripts for reproduction film outputs is completed if a diskette recoding the data is sent to the output side. In this regard, there would be no problem if the film output work were subcontracted to any company in a country outside Guatemala such as Mexico. In any case, there is an urgent necessity to find a business partner who can cooperate with IGN in the film output work.

(2) Hardware

With the background that the digital printing (hereinafter DTP) development had been promoted using Macintosh of Apple Inc., Macintosh is still superior to Windows in terms of DTP environment even if the DTP-related software on Windows is prepared. In fact, in the case of film output from an image setter, most of the manuscripts are provided after they are converted into files in the Macintosh format. Therefore, it is desirable to prepare the environment that allows the Macintosh OS-based hardware to be used effectively as a platform for final data reception.

(3) Software

The lecture on AdobeIllustrator was undertaken for the technology transfer to Guatemala. This graphic software is also provided with the function for importing photo images. Single-page maps, namely map sheets can be printed on this software, but it is recommended to acquire the operation of the following software:

- Image processing software (AdobePhotoshop provided)
  This software is capable of freely processing and compiling photo data imported from a scanner. The software can perform various types of processing such as clipping, composite,

partial retouch, contrast adjustment and color adjustment. For the color- proof samples of the "Hazard Map" provided in the fifth field survey, this software was used to perform the contrast adjustment for printing of orthophoto data arranged on AdobeIllustrator.

- Page layout software (typically, QuarkXpress or PageMaker available)
  Single-page maps can be finally processed on AdobeIllustrator, but it is more effective to use the page layout software when creating the data for multi-page maps of an atlas type. If attaching a volume of map data, text data and photo data to each sheet completes the map sheets, it would be possible to compile an atlas.

Thanks to the use of the above software, the range of available products will be more expanded.

(4) Effective use of existing data (GIS database)

The map production processes have already been digitalized. In other words, it is more suitable to process digital data in all the processes than to proceed with the analog production. For this purpose, the GIS database is available. This matter is important for this technology transfer project.

(5) Social contribution by digital maps

Digital map data can be disclosed to the public on Internet and only changing its layout for distribution to citizens can easily produce the map representing evacuation routes in case of a disaster. The production and sale of atlas-type maps may create new opportunity of businesses and the valuable data should be made available to the public.

The present problems and solutions and the recommendations for the future development in the digital printing project have been described above. In any way, it is necessary for Guatemala to establish a method for producing digital printing maps independently through repeated try and error efforts.

6.2.4 Current tasks in IGN and INSIVUMEH and proposals for the future

It is commonly said that any organization is expected to constantly grow. In particular, a modern organization with an operational setup based on the electronic technologies should grow at a speed not comparable to any other in the past.

The main operations of the two organizations, i.e., development of topographical maps and GIS databases and development of hazard maps will be fully digital in a few years. In other

words, the organizations must switch to an operation type based on electronic technologies.

There are three immediate tasks for the two organizations in order to catch up with the progress of these basic technologies, and they are (1) developing human resources, (2) investing in equipment, and (3) securing budgets.

These are the major requirements of which an organization must always consider.

In the Study, JICA provided equipment toward this goal and undertaken technology transfer required to make the most of the equipment. Namely, equipment and operation technologies minimally required for digitization remain with IGN and INSIVUMEH.

For a new expansion in the future, it is essential that the organizations maintain and manage this equipment and further educate their engineers. They will be thus able to maintain and manage the products of the Study, complete digital databases that cover the entire country at an early date, and even develop large-scale topographical maps of urban areas, now suffering from many problems. For these tasks, we would suggest the following proposals as specific examples:

(1) Developing human resources

① Fostering experts

- It is required to foster experts as early as possible, based on the original operations of GIS such as structuralizing and using databases.
- Since this requirement depends on the utilization of software in many cases, offer the experts as many opportunities to participate in external seminars as possible.

② Fostering routine workers

- Reassign engineers who were in charge of editing and scribing, to digital mapping and construction of its database.
- This operation is not only aimed at digitizing data but also figuring out minute errors that could be ignored on analog maps.
- Since people who understand the original meaning of topographical maps are the right persons for the operation, skilled engineers can be assigned.

(2) Investing in equipment

① Maintaining and upgrading main equipment

- As described earlier, it is required to support new hardware and software in order to deal with the current rapid evolution of equipment (both hardware and software).

- At the same time, the introduction of new equipment must be also considered.

② Maintaining and upgrading peripheral equipment
- Not only the equipment to be used for mapping and GIS but also its peripheral devices must be considered.
- The major items are input-output devices for databases and faster intranets in government office buildings. Since the equipment is normally required to handle increasing amount of data as it evolves, saving, moving, and using the data will be more difficult year by year unless the equipment is upgraded.

③ Maintaining and upgrading equipment donated by JICA
- As described in Paragraph 2-1, the equipment donated for this Study should be maintained and upgraded.
- The software and hardware must be upgraded to the latest version at least once every year. Leaving the software and hardware as they are for three or four years will make their functionality so obsolete, impeding thus to exchange data with or distribute data to other organizations.
- It is necessary to maintain and upgrade the equipment in order to develop national databases on your own in the future.

(3) Securing budgets

① Budgets for maintaining and upgrading equipment
- As described earlier, the equipment (both hardware and software) is rapidly evolving. To deal with the evolution, you need to secure budgets so that you can support hardware and software in their newer versions.
- At the same time, it is necessary to keep track of new equipment and its necessity and to examine whether it needs to be introduced.

② Revenue sources
- So far, the sales performance of maps has been managed inside IGN. However, when the Study is completed, the organization will be able to sell products that were not available before (such as GIS and orthophotomaps and the databases), increasing thus the sales.
- We propose that IGN put aside part of the sales every year as budgets for the aforementioned maintenance and management.
- These revenue sources will prove useful as budgets for maintenance and management

of the existing databases and as stepping stones to the next stage of development.

6.2.5 Proposals for disaster prevention

(1) National level

① The nation constitutes the most basic unit of disaster prevention activities. The national agencies must make a great effort on the national disaster prevention plans of various countries in progress at the moment. Currently, the concerned agencies are successfully cooperating and sharing tasks with CONRED operating as the central figure. However, each agency is not provided with sufficient human and physical resources. The disaster prevention must be improved through the efforts of the Guatemalan government and the effective assistance from the donor nations and agencies. Hazard maps should not end up as mere maps but should be used positively for evacuation and land use plans. Figure 6.2-2 shows an idea of evacuation areas. It is recommended that hazard maps, intended to protect the lives and properties of local residents, should evolve into disaster prevention maps.

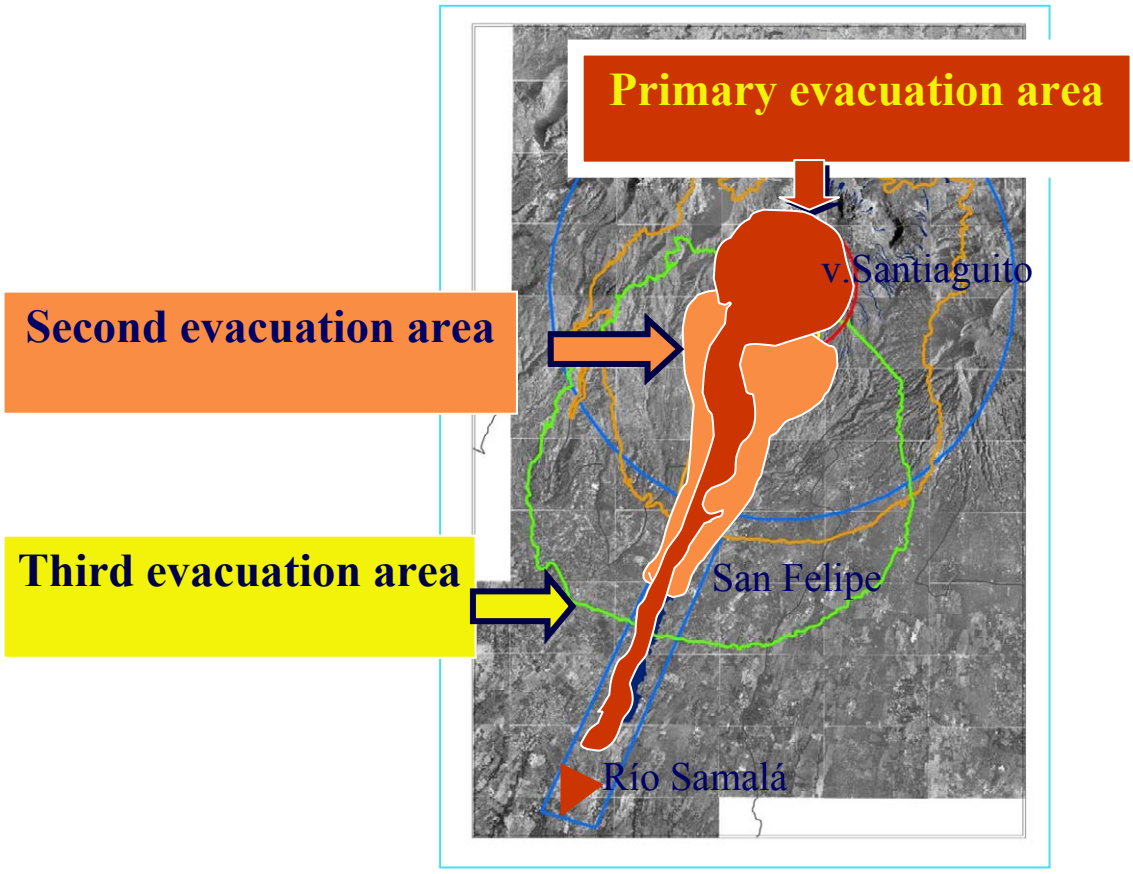

Figure 6.2-2 Idea of evacuation areas based on hazard maps

② INSIVUMEH, that supplies prompt and accurate information on the present conditions and estimation of natural phenomena to agencies related to disaster prevention, must actively promote the enhancement of observation devices and software for analysis devices and GIS, and reinforcement of observation and analysis engineers. For sufficient disaster estimation, the observation networks must be improved in order to acquire meteorological, seismological, and volcanic observation data at appropriate intervals. Forecasts based on observation are indispensable in alleviating meteorological and volcanic disasters. It is recommended to ensure an effective provision for observation and INSIVUMEH should continue to improve the hazard maps on its own, based on the results and experiences of the Study.

(2) Department level

In the department level, a catchment area or basin, for example, should act as a unit of disaster prevention activities. The department-level hazard map to be created in the Project should be used to develop a safe and attractive region by making a wide-area land use plan, for example, in view of disaster prevention, restriction on tree planting and logging. This would also establish a production system as a region and thus decrease the number of people who have no choice but to leave their villages.

In the following example, we investigated the places actually hit by lahar disasters in June 2002 and proposed disaster prevention measures. As shown in Figure 6.2-3, we created a disaster map using an orthophoto map created in the Project. Furthermore, we proposed a river improvement plan for each mountain stream (Table 6.2-1).

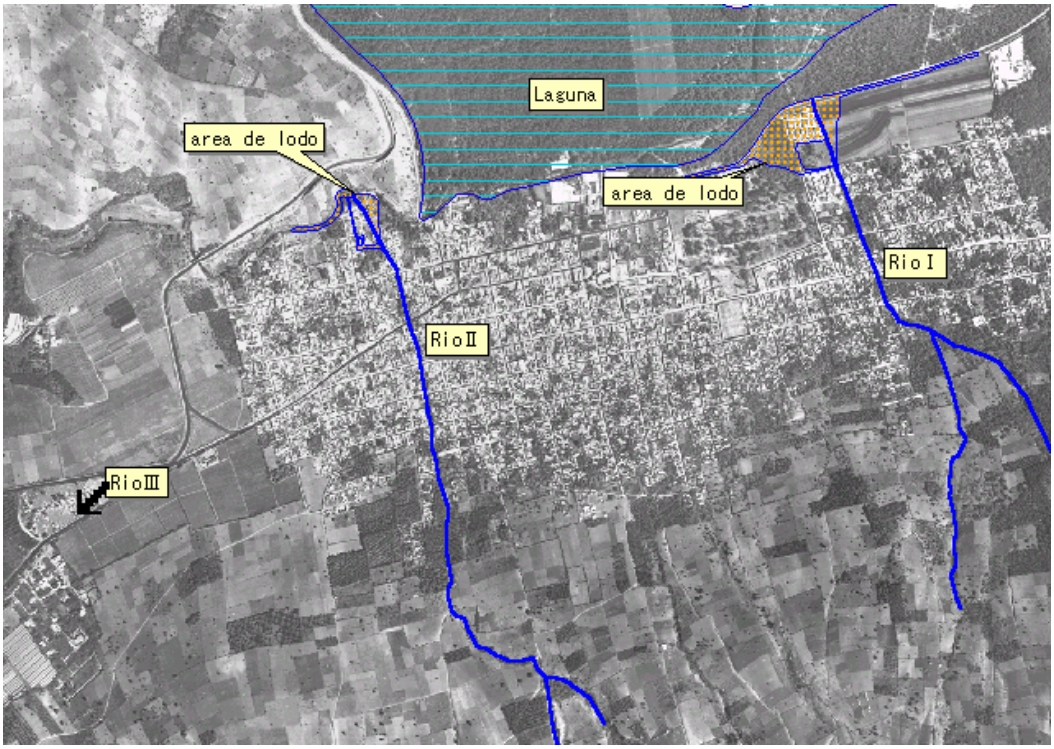

Figure 6.2-3 Disaster map of Ciudad Vieja on June 13, 2002

Outline of proposed countermeasures

In Ciudad Vieja, an old capital built on the mountain foot of a volcano with the urban area spreading over an alluvial fan, it is extremely difficult to widen the river path. Revetments must be constructed because lahar sediments are produced through lateral erosion. The peak water discharge tends to be large because the land along the upper reaches of the river is used as farms. As much tree planting as possible should be promoted.

Table 6.2-1 Proposals for river improvement (example)

	Stream I	Stream II	Stream III
Upper reaches	Planting trees	Planting trees	Planting trees
Middle reaches	Widening the river path and constructing revetments (gabions, etc.)	Widening the river path and constructing revetments (gabions, etc.)	Widening the river path and constructing revetments (gabions, etc.)
Lower reaches	Widening the river path, excavating raised river beds, and improving the end part of river current	Widening the river path, excavating raised river beds, and widening the river path in bridge sections	Widening the river path and installing large-diameter culverts

(3) Municipality level

A municipality must increase the disaster prevention of communities by providing them with the appropriate guidance. Using hazard maps created in the Project, a municipality would ensure education and guidance on disaster prevention to the residents. Furthermore, a municipality should make great efforts to eliminate vulnerability by, for example, restricting land use in hazard areas. The engineers of INSIVUMEH must explain the hazard maps to the local governments in a user-friendly manner in order to help improve the local disaster prevention.

(4) Community level

Residents must understand that both sustainment and safety of life are mutually compatible. They must be highly aware about disaster prevention so that not only people in this generation but also their children and grandchildren can live in a safe housing environment. They must also recognize that, spatially, cities and villages, upper and lower reaches, and areas up and down cliffs are linked among them in terms of disaster prevention. The upper level organizations must provide information while adopting a vocabulary that is easy to understand.

Recommendations for project implementation of the disaster prevention plan formulation

6.3 Recommendations for project implementation of the disaster prevention plan formulation

6.3.1 Types of disaster prevention plans

Schemes for disaster prevention can be classified into three types:

① Extensive disaster prevention scheme in which neighboring countries cooperate with each other across borders,

② National disaster prevention scheme in which one country plans and implements disaster prevention measures, and

③ Local disaster prevention scheme in which municipalities take the lead while promoting understanding and cooperation of local residents.

These types of schemes, with different scales, must operate in their own levels and interact with each other so that these entities can organically link up and achieve the main objective of "protecting people and their properties against natural disasters."

The following sections describe the representative tasks that these schemes are expected to play.

(1) Extensive disaster prevention (disaster prevention measures for a region across countries)

<Roles of organizations related to extensive disaster prevention>

- Exchange information and share experiences to alleviate damages that people in Central America may suffer due to natural disasters.
- Collect, process, and analyze scientific data across countries and integrate the results to prepare for extensive disasters.
- Provide citizens with education for emergency measures and create an international cooperation network.

  Specifically,

  * Holding courses, seminars, and expert programs
  * Establishing scholarships for receiving technical training
  * Collecting contributions
  * Setting up common observation stations in the region
  * Establishing economic and technical liaisons

(2) National disaster prevention (Disaster prevention measures for a country)

To protect people and their properties against damages caused by natural disasters, the national government needs to create systems including the basic disaster prevention policies, overall coordination of measures related to disaster prevention, and plans related to emergency measures during disasters.

<Roles of the government>

- Collection of information
- Emergency measures for disasters
- Emergency transport
- Procurement and supply of food and other necessities
- Evacuation accommodation activities
- Acceptance of support
- Disaster prevention drills in which local governments and residents work together
- Other (preparation of laws and regulations in terms of disaster prevention including, for example, priority aid to the vulnerable at the time of disasters)

(3) Local disaster prevention (disaster prevention measures for a locality)

To minimize damages caused by natural disasters, it is important to prepare for such disasters so that each citizen can protect himself. To this end, citizens must have accurate knowledge on disasters, develop a better understanding of the situation, and make preparations including checking the locations of evacuation sites and stockpiling water and food.

<Roles of a local government>

- Meticulous disaster prevention measures

  Cooperate with the locality to create appropriate prevention and self-defense measures for the sake of the vulnerable at the time of disasters such as senior citizens. Provide support to increase houses and facilities more resistant to natural disasters.
- Development of networks for distributing emergency information

  Develop measures for distributing emergency information and provide without fail information including opening of evacuation sites and evacuation orders to citizens. Provide means of cooperation between towns and villages or with neighboring cities.
- Enhancement of stockpiling and facilities related to disaster prevention

  Properly place facilities for quick responses and disaster prevention centers with a stockpiling function. Review evacuation sites and enhance the resistance of the first aid centers and public facilities to natural disasters.

- Enhancement of autonomous disaster prevention organizations

  Aim at reinforcing the autonomous disaster prevention through disaster prevention seminars, disaster prevention drills, etc.
- Provide citizens with information using disaster prevention maps and hazard maps.
- Support the development of autonomous disaster prevention organizations and hold disaster prevention seminars.
- Distribute articles for autonomous disaster prevention.

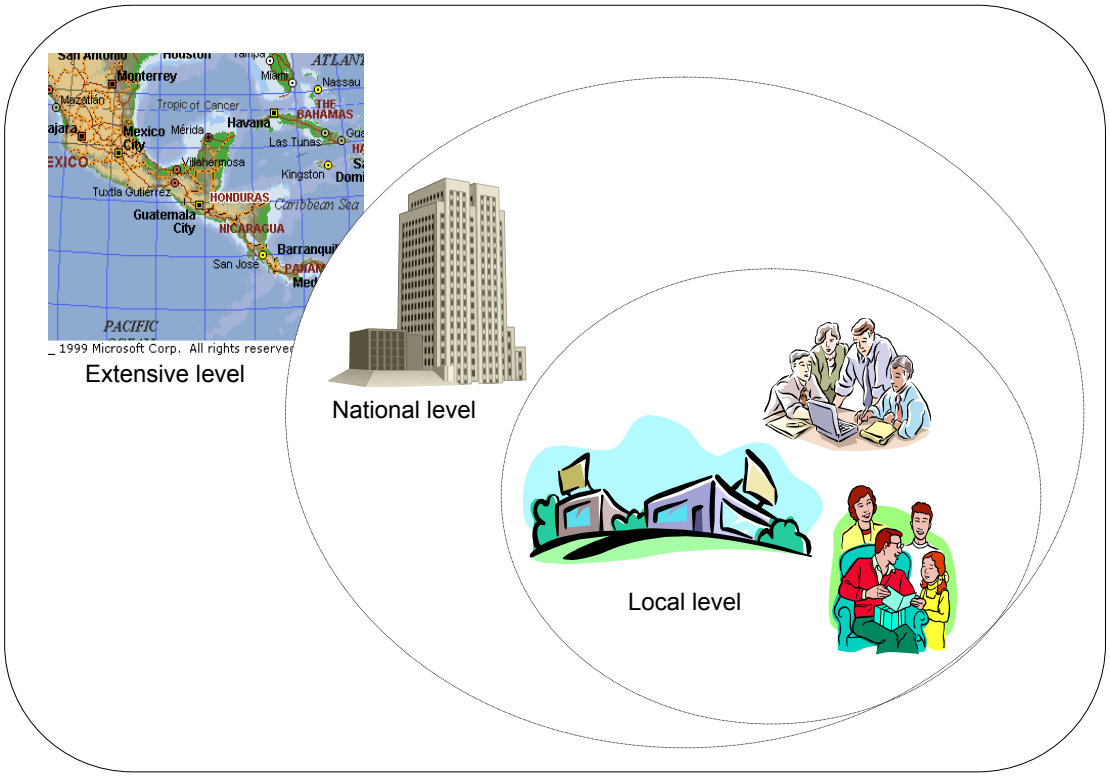

Figure 6.3-1 Disaster prevention schemes

6.3.2 Local disaster prevention and use of hazard maps

The first step to local disaster prevention is to identify the location and nature of disaster hazards. The use of hazard maps is essential for this purpose.

A hazard map is a map showing specifically where and how target disasters are likely to occur.

For an efficient use of the hazard maps created in the Project, the "enhancement of local disaster prevention", directly connected to protection of citizens and their properties, represents the most importance of the aforementioned three levels of disaster prevention schemes.

This is based on the concept that disaster prevention can be promoted only if the local residents are well aware of disaster hazard locations and what to do when a disaster occurs.

Table 6.3-1 Achievements of the Project related to hazard maps

Earthquakes: Guatemala City (1:50,000 scale), Quetzaltenango, Mazatenango, Escuintla, and Puerto Barrios (1:20,000 scale) **Volcanos:** Santiaguito, Cerro Quemada and Pacaya volcanoes (1:25,000 scale) , Tacana volcano (1:50,000 scale) **Landslides:** Guatemala City, Quetzaltenango and Antigua (1:25,000 scale) , Slope classification map for Northwest region (El Quiche, Huehuetenango, San Marcos) and Central region (Sacatepequez, Chimaltenango, Solola) (1:50,000 scale) **Floods:** Samala Basin, Acome Basin, Achiguate Basin and Maria Linda Basin (1:25,000 scale)

Generally, a hazard map can be created in three steps, namely:

① Creating a map for experts through study,

② Creating a map for public administration based on the first map, and

③ Creating an easy-to-understand map for education of residents based on the second map and then distributing it to the residents.

The Project created four types of hazard maps, namely those for volcanoes, earthquakes, landslides, and floods. These are considered to be ① maps for experts, created in the first phase. In the future, it is important that INSIVUMEH, CONRED, and the local governments cooperate with each other to create ② maps for public administration, which the local governments can use to implement local disaster prevention plans and measures and, ③ easy-to-understand disaster prevention maps for education of residents, that allow the residents to understand the locations and nature of disaster hazards and take appropriate action when a disaster occurs. These maps need to be developed promptly.

INSIVUMEH is in charge of storing, processing, and analyzing scientific data while CONRED is in charge of emergency action and measures. While the cooperation of these two organizations is important, we recommend to continue creating and using hazard maps in cooperation with IGN that create topographical map and GIS databases, to be used as the foundation of map information, and with SNIG, a liaison and coordination agency for GIS in Guatemala.

6.3.3 Enhancement of functionality of the emergency action and measures organization

CONRED is in charge of emergency action and measures and assumes the role of national disaster prevention in one of the aforementioned schemes. On the other hand, some local governments and other organizations are not provided with sufficient systems or accumulated knowledge for local disaster prevention, in which case CONRED takes the initiative on their behalf, to act as a key organization in local disaster prevention in Guatemala in the future.

The tasks of CONRED include the aforementioned items listed as the disaster prevention measures for the country and for a locality.

To enhance the disaster prevention measures for the country, it is necessary to focus on the following items:

① Creating frameworks for sustainable development of disaster prevention measures:

- Legal framework
- Securing budgets
- Definition of responsibilities to be shared among related organizations

② Making preparations at normal times:

Collect and analyze data on natural and social conditions in preparation for influences from disasters.

③ Securing the governing function:

The scale of damages caused by natural disasters will expand under the influence of social conditions and human behaviors. Thus, make preparations so that the governing function will be efficient when a disaster occurs.

④ Protecting people and their properties:

Deal with the problems concerning supply and replenishment of goods and the social infrastructure required for them to protect people and their properties.

⑤ Enhancing the socio-economic systems

Since the fragility of social infrastructures leads directly to the vulnerability in case of disasters, it is indispensable to strengthen the socio-economic system in order to minimize damages.

On the other hand, we suggest to select a model area and to undertake a project so that the disaster prevention for the locality can be implemented normally.

Select a model area from the areas on which hazard maps were created in the Project and have CONRED create a local disaster prevention plan as an example using hazard maps. Furthermore, CONRED should work with a local government to carry out educational activities for residents in the target area.

It is important that CONRED cooperates with and instructs other local governments based on this implementation example, in order to actively implement the disaster prevention measures in the local level.

In conclusion of "Proposals for disaster prevention," we recommend that Guatemala launch at an early date the next project, "Community Disaster Management Project." CONRED shall be an implementing agency for this project with collaboration from Western countries and Japan, a country with a history of many disasters. Of course, the implementation shall be built on all the products and technologies acquired in the Study.