

Country Name	Research Project on Enhancement of Technology to Develop Tsunami-Resilient Community
Republic of Chile	

I. Project Outline

Background	<p>Chile was a country located in the circum-Pacific seismic belt, and prone to earthquakes and tsunami. In 2010, an earthquake of magnitude 8.8, which was the sixth-largest earthquake in the world, occurred and caused widespread damage. In particular, damages caused by Tsunami were serious and left us many lessons learned, such as: 1) secondary damages in residential areas and distant coastal areas caused by containers which drifted from ports, 2) delay of tsunami alert, 3) further human suffering by the second and third tsunami due to some wrong announcement and hasty cancellation of alert by the government made people return to their residents, 4) slow reconstruction and rehabilitation of port infrastructure which has important role for reconstruction of the local economies and communities. To deal with these issues, some countermeasures were taken in Chile such as installation of seismometers and simplification of tsunami warning procedure. However, research on tsunami was not accumulated sufficiently and the number of researchers in this field was limited.</p>												
Objectives of the Project	<p>Through development of mathematical simulation models for tsunami damage, precise tsunami warning method as well as proposal of tsunami disaster estimation and mitigation measures, the project aimed at developing technologies and measures to improve resilience of communities and people in Chile against tsunamis.</p> <p>1. Expected Overall Goal: N.A.</p> <p>2. Project Purpose: Technologies and measures are developed to improve communities and people in Chile, Japan and across the world to be well-prepared and resilient against tsunamis.</p>												
Activities of the Project	<p>1. Project Site: Santiago, Valparaiso, Talcahuano, Iquique, Antofagasta, Chile</p> <p>2. Main Activities: 1) Development of mathematical simulation models for tsunami damage, 2) Development of tsunami disaster mitigation measures including development of a guideline for tsunami disaster estimation, 3) development of precise tsunami warning systems, 4) Development of programs to create well prepared and resilient people against tsunamis, and 5) Development of a methodology to improve recovery capacity by utilizing ports and harbors after a tsunami disaster with use of Japanese experiences as references.</p> <p>3. Inputs (to carry out above activities)</p> <table border="0"> <tr> <td>Japanese Side</td> <td>Chilean Side</td> </tr> <tr> <td>1) Experts: 37 persons</td> <td>1) Staff allocated: 36 persons</td> </tr> <tr> <td>2) Trainees received: 54 persons</td> <td>2) Facilities and land: one office in Pontifical Catholic University of Chile (PUC), and one office in Department of Port Works (DOP)</td> </tr> <tr> <td>3) Equipment: Simulation and data analysis equipment (parallel computation equipment) and UPS.</td> <td>3) Local operation cost: salaries of counterpart staff, travel cost, workshop and meeting costs, etc.</td> </tr> <tr> <td>4) Local operation cost: travel cost, employment of local consultants, etc.</td> <td></td> </tr> </table>			Japanese Side	Chilean Side	1) Experts: 37 persons	1) Staff allocated: 36 persons	2) Trainees received: 54 persons	2) Facilities and land: one office in Pontifical Catholic University of Chile (PUC), and one office in Department of Port Works (DOP)	3) Equipment: Simulation and data analysis equipment (parallel computation equipment) and UPS.	3) Local operation cost: salaries of counterpart staff, travel cost, workshop and meeting costs, etc.	4) Local operation cost: travel cost, employment of local consultants, etc.	
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Project Period	January 2012 – March 2016	Project Cost	(ex-ante) 383million yen, (actual) 344million yen										
Implementing Agency	<p>Department of Port Works, Ministry of Public Works (DOP/MOP), National Hydraulic Institute (INH), Hydrographic and Oceanographic Service, Chilean Navy (SHOA), National Emergency Office, Ministry of Interior (ONEMI), Pontifical Catholic University of Chile (PUC), Catholic University of the Most Holy Concepcion (UCSC), Federico Santa María Technical University (UTFSM), North Catholic University (UCN), Concepcion University (UdeC), Valparaiso University (UV)</p>												
Cooperation Agency in Japan	<p>Port and Airport Research Institute (PARI), Urban Disaster Research Institute, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan Meteorological Agency, Kansai University, Disaster Prevention Research Institute (Kyoto University), Nagoya University, Chuo University, Tsukuba University, Tokushima University, Shizuoka University, Gunma University, Hiroshima University, Yamaguchi University</p>												

II. Result of the Evaluation

<Special Perspectives Considered in the Ex-Post Evaluation>

- Since the Overall Goal for the SATREPS project was not set in the project design, “Utilization of the research outcomes” was verified by this ex-post evaluation as a part of expected positive impacts by the SATREPS project.
- Since indicators 1-2 of Project Purpose are indicators for validating opportunities for sharing research outcomes during the project implementation period, the continuation status of indicator 1-2 was not verified by this ex-post evaluation.
- Since indicator 3 of Project Purpose is an indicator for verifying capacity enhancement of Chilean counterparts who were dispatched to Japan, its continuation status was verified in sustainability.

1 Relevance

<Consistency with the Development Policy of Chile at the Time of Ex-Ante Evaluation>

The project was consistent with the Chile’s development policy of “the National Civil Protection Plan” (2002) and “the National Policy for the Disaster Risk Management” (2014) emphasizing on the capacity enhancement of disaster prevention and management of the country.

¹ SATREPS: Science and Technology Research Partnership for Sustainable Development.

<Consistency with the Development Needs of Chile at the Time of Ex-Ante Evaluation>

The project was consistent with the Chile's development needs of strengthening of preparedness and resilience of people and community in Chile against tsunami.

<Consistency with Japan's ODA Policy at the Time of Ex-Ante Evaluation>

The project was consistent with the Japan's Country Assistance Policy for the Republic of Chile at the time of ex-ante evaluation putting priority on the environmental policy centered on disaster prevention as mentioned in its basic policy for the assistance².

<Evaluation Result>

In light of the above, the relevance of the project is high.

2 Effectiveness/Impact

<Status of Achievement of the Project Purpose at the time of Project Completion>

The Project Purpose was achieved by the time of project completion. Six symposiums were held in the operation period of the project to show project activities and their results. These symposiums were organized jointly with on-going SATREPS projects in Peru, Colombia, Mexico and Turkey as well as JICA technical cooperation project in Ecuador (Indicator 1). The Symposium on Earthquake and Tsunami Disaster Prevention in Latin America was organized in Tokyo in March 2014 jointly with on-going SATREPS projects in Peru, Mexico and Turkey as well as JICA technical cooperation project in Ecuador³ (Indicator 2). In addition, the Chilean members involved in the SATREPS project made a presentation on the project activities at the International Symposium on Earthquake and Tsunami Disaster Mitigation co-hosted by JICA, Japan Science and Technology Agency (JST), and National Research Institute for Earth Science and Disaster Prevention (NIED) organized in Sendai in March 2012. Total 54 Chilean researchers and government officials were invited to Japan to participate to trainings, seminars/workshops and international symposiums for their capacity enhancement on tsunami risk management (Indicator 3). A guideline for estimation of tsunami inundation and damage which contained the methodologies of tsunami propagation and inundation simulation, as well as damage estimation was established. In addition, various guidelines and materials were developed (Indicator 4).

<Continuation Status of Project Effects at the time of Ex-post Evaluation>

The project effects have been continued by the time of ex-post evaluation. The guidelines developed by the project have been utilized by counterpart agencies. For example, the National Research Center for Integrated Natural Disasters Management (CIGIDEN), which is an inter-university research organization established in 2012 based on the proposal of this target project and PUC, UTFSM, UCN are its member universities, and UV, UCSC, UdeC are collaborated universities), has utilized the guidelines established by the project for further research activities including: a) Guideline for breakwater anti-tsunami design, b) Guideline for estimation of tsunami inundation and damage, c) Guideline for mathematical simulation models for estimation of tsunami damage, d) Guideline for Integrated System for Tsunami Prediction and Warning (SIPAT), e) Guideline for Implementation of Disaster Imagination Game (DIG), f) Guideline for disaster education, g) Tsunami Mitigation Measures Menu, and h) Guideline for Port Business Continuity Management (BCM). UdeC has utilized e) and f) for research activities on evacuation model in the city of Talcahuano. DOP/MOP and INH have utilized a)-c) for design of port and mitigation of damage. SHOA has utilized b) and d) for early warning system and tsunami inundation estimation. UV supported to introduce h) to the port of Valparaiso.

Also, research activities based on the project outputs have been continued. For example, CIGIDEN continues research activities on tsunami estimation of damage, simulation of inundation, prediction and warning system, vertical evacuation, education of communities, etc. UTFSM continue research activities to improve the SIPAT as well as to contribute to the strengthening of the warning system of tsunami manage by SHOA. UV continues research activities related to the BCM of ports and coastal cities. UdeC continues activities related to the effective evacuation, including not only the communities but also to the industries, and the vertical evacuation. The high-performance computer and UPS are still utilized by CIGIDEN and PUC to analyze the data collected for research activities and for share it with other universities involved in CIGIDEN.

<Status of Achievement for Expected Overall Goal at the time of Ex-post Evaluation>

Since no Overall Goal was set, utilization of the research outcomes was verified as a part of expected positive impacts. The utilization of the research outcomes of the SATREPS project have been promoted at the time of ex-post evaluation. SIPAT has been still utilized by SHOA and improved over the years. After the project for two years with the Fund for the Promotion of Scientific and Technological Development (FONDEF), the database of tsunami was completed. The following years with SHOA funds have trained system operators, developed an automatic calculation system and the software was upgraded. Since the end of 2019, a new project is being developed with the FONDEF which seeks to develop a real-time modelling, and can be determined where they will not reach tsunami waves. All these initiatives have been led by UTFSM. DOP/MOP continues utilizing the Storm Surge and Tsunami Simulator in Oceans and Coastal Areas (STOC) model to simulate the damage of the port infrastructure. UV has a collaboration with the port of Valparaiso-San Antonio, the regional government of Valparaiso, municipalities of Valparaiso and San Antonio, and industries to introduce the BCM activities. CIGIDEN developed the policy paper on vertical evacuation based on the multiple research and publications developed in recent years, which was delivered to ONEMI in 2019. Based on this, a working group was formed between ONEMI, the Ministry of Housing and Urbanism (MINVU), CIGIDEN and others to analyze and discuss the necessary regulations for the implementation of a vertical evacuation.

<Other Impacts at the time of Ex-post Evaluation>

The results of this SATREPS Project was taken over and disseminated by the on-going JICA technical cooperation "Disaster Risk Reduction Training Program for Latin America and the Caribbean" (2015-2020) (so called the Kizuna project) to the Latin America and the Caribbean countries to contribute to resilience to natural disasters.

<Evaluation Result>

Therefore, the effectiveness/impact of the project is high.

² Japan's ODA Data Book by Country (2012), Ministry of Foreign Affairs, Japan.

³ The Project for Enhancement of Tsunami-genic Earthquake Monitoring Capability (2014-2017).

Achievement of Project Purpose and Overall Goal

Aim	Indicators	Results
(Project Purpose) Technologies and measures are developed to improve communities and people in Chile, Japan and across the world to be well-prepared and resilient against tsunamis.	(Indicator 1) Four symposiums are held in the operation period of the project to show project activities and their results.	<u>Status of the Achievement: Achieved (Not verified)</u> (Project Completion) • Total six (6) symposiums were held during the project period, which were organized jointly with on-going SATREPS projects in Peru, Colombia, Mexico and Turkey as well as JICA technical cooperation project in Ecuador. (Ex-post Evaluation) • Not verified.
	(Indicator 2) One international symposium with participation of other countries than Chile and Japan will be held at the end of the project.	<u>Status of the Achievement: Achieved (Not verified)</u> (Project Completion) • With participation of other countries than Chile and Japan, the Symposium on Earthquake and Tsunami Disaster Prevention in Latin America was organized in Tokyo in March 2014. (Ex-post Evaluation) • Not verified.
	(Indicator 3) Fifty Chilean researchers and officials are dispatched to Japan for enhancement of their capabilities on tsunami risk management.	<u>Status of the Achievement: Achieved (Continued)</u> (Project Completion) • Total 54 Chilean researchers and government officials were invited to Japan to participate to trainings, seminars/workshops and international symposiums for their capacity enhancement on tsunami risk management. (Ex-post Evaluation) • Verified as “Sustainability”.
	(Indicator 4) A guideline is developed to show a method to estimate tsunami damage especially applied in Chile.	<u>Status of the Achievement: Achieved (Continued)</u> (Project Completion) • A guideline for estimation of tsunami inundation and damage which contained the methodologies of tsunami propagation and inundation simulation, as well as damage estimation was established. • In addition, various guidelines and manuals were developed. (Ex-post Evaluation) • The guidelines developed by the project have been utilized by counterpart agencies. • CIGIDEN members have continuously conducted researches on Guideline for mathematical simulation models for estimation of tsunami damage, Guideline for Integrated System for Tsunami Prediction and Warning (SIPAT), BCM guideline, Vertical evacuation, and on estimation of potential damage caused by tsunami in coastal cities, such as Iquique, Vina del Mar and others.

Source: Questionnaire and interviews

3 Efficiency

Both the project cost and project period were within the plan (90% and 100% respectively). The outputs were produced as planned. Therefore, efficiency of the project is high.

4 Sustainability

<Policy Aspect>

The National Policy for the Disaster Risk Reduction (2019-2030) addresses five priority issues such as: 1) understanding of disaster risk, 2) strengthening the governance; 3) planning and investing on DRR for resilience; 4) efficient response; and 5) promote a sustainable recovery.

<Institutional/Organizational Aspect>

Almost all the researchers involved to the project are still engaged to research activities. CIGIDEN has 50 staff including principal researchers, associate researchers, researcher for some topics, postdoc students, administrative staff. CIGIDEN promotes the DRR mainstreaming and shares the new research outputs through participating to the National Platform of DRR coordinated by ONEMI. Also, CIGIDEN becomes known in the country as one of the most important research centers on natural disasters and that makes public proposals. DOP/MOP established a new department in charge of DRR management, and utilizes STOC to able to estimate the possible damage of port facility. SHOA, ONEMI, PUC, UCSC, UTFSM (CIGIDEN members) have been working for maintaining and improving the SIPAT for early warning with the support from FONDEF.

<Technical Aspect>

There are more than 48 domestic and international journals, paper and others published after the project, in topics such as tsunami mitigation, mitigation measures, numerical model, tsunami evacuation, wave propagation, tsunami early warning, etc. Through the Kizuna project, researchers have been able to maintain contact with Japanese researchers and this has contributed to developing and expanding new research topics. The government authorities have sustained/improved their scientific literacy to utilize the research outcomes by the STREPS project. SHOA in collaboration with UFSTM (CIGIDEN) continue to improve SIPAT and to incorporate an inundation estimation model. ONEMI continue to improve the evacuation drill based on the guideline generated by the project. CIGIDEN collaborated with MINVU and ONEMI to develop a guideline for evacuation. Also, the researchers have been sustaining their skills and knowledge to properly operate and maintain the research facilities/equipment installed by the STREPS project. The high-performance computer for

running the numerical model installed by the project has been operated and maintained without major issues. CIGIDEN and PUC have a team in charge of mathematical estimation and calculation, and they have consistently improved their skills. All the data obtain are being store and share in CIGIDEN website⁴.

<Financial Aspect>

CIGIDEN received a fund of approximately USD 5,600,000 for the period of 2018-2022 from FONDAP managed by the National Commission for Scientific and Technological Research, Ministry of Education (CONICYT). They also obtained a fund from CONICYT for specific research for technological development with practical application. The operation and maintenance budget for the project equipment is secured by related organizations.

<Evaluation Result>

Therefore, the sustainability of the effects through the project is high.

5 Summary of the Evaluation

The project achieved the Project Purpose and the project outcomes have been utilized through the continuous research works on disasters of tsunami as well as the continuous activities for disaster management based on the research output by the project. The efficiency and sustainability of the project are high. Considering all of the above points, this project is evaluated to be highly satisfactory.

III. Recommendations & Lessons Learned

Recommendations for Implementing Agency:

- Considering that the FONDAP funding period will end to 2022, it will be necessary to take steps to obtain financial resources to continue improving the research activities and promote the DRR in the public policies of Chile. For this aim, it is important to continue to develop research that helps to solve the challenges that the country faces and that have a practical application. In addition to maintaining the close relationship with public and private institutions built during the project implementation period, it will be beneficial.

Lessons Learned for JICA:

- From the beginning and during the project implementation period, the involvement of all institutions that would possibly be the beneficiaries of the project results was considered. In order to promote the better understanding and build a confident relationship, seminars were also organized with the participation of, or jointly organized with these institutions. In addition, the Japanese researchers periodically shared the progress of the project with stakeholders. This promoted the collaborative work of academia central and local government, and the participation of multi-stakeholders in the project facilitated the outputs to be utilized. Therefore, it was found that the sharing information, promoting understanding, and collaborating with beneficiaries of the outcome of SATREPS in a proactive manner during the project implementation period had led to promote the utilization of the outcome of SATREPS. This approach will be a good reference to other SATREPS.
- Since the beginning of the project, the importance of sharing the project results through south-south cooperation with Latin American countries that have the same natural disasters was considered to contribute to the resilience of this Region. In this regard, in order to ensure that the beneficiary countries of Kizuna Project could smoothly accept the SATREPS project results, the SATREPS implementing agencies actively exchanged information with DRR projects in the Region which were based on the same Japanese experiences and technologies. In addition, Kizuna project was designed, based on the assumption that the highly qualified human resources and administrative officers trained by SATREPS project would be utilized as valuable project resources. Therefore, it was found that a collaboration with other projects aiming to solve common problems with the SATREPS was useful for sharing and utilizing the outcome of SATREPS. This approach will be a good reference to other SATREPS projects.



Meeting with Chilean stakeholders on evacuation training against Tsunami in Antofagasta Region



Test tank facilities at National Hydraulic Institute

⁴ <https://ide-cigiden.hub.arcgis.com>