

Republic of the Union of Myanmar
Ministry of Education

**PROJECT COMPLETION REPORT
ON
THE PROJECT FOR
DEVELOPMENT OF A COMPREHENSIVE
DISASTER RESILIENCE SYSTEM AND
COLLABORATION PLATFORM IN MYANMAR**

JULY 2020

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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The Project Completion Report

Project Title: Development of a Comprehensive Disaster Resilience System and Collaboration Platform in Myanmar

Name: DG of MoHE

Title: Project Director

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Title: Principle Investigator

Submission Date: 7 April 2020

I. Basic Information of the Project

1. Country:

Republic of the Union of Myanmar

2. Title of the Project

Development of a Comprehensive Disaster Resilience System and Collaboration Platform in Myanmar

3. Duration of the Project (Planned and Actual)

Five years from 7th April 2014 to 31st March 2020 (both planned and actual)

4. Background (from Record of Discussions(R/D))

4-1 Current Status and Challenges of disaster management in the Republic of the Union of Myanmar

The Republic of the Union of Myanmar is highly disaster-prone country. It is affected by frequent floods such as the flood in Yangon and Ayeyarwady Delta caused by Cyclone Nargis in 2008, the flood in the Bago River Basin in 2010 and 2011, and the large-scale flood in south-east of the country in 2013. Also, there are several faults lay in the country, and major cities including Yangon, Mandalay, and Nay Pyi Taw lie on or near the Sagaing fault. Recent political transition accelerates economic activities, and high growth is expected. However, disaster risk is also expected to rise due to rapid land development, population growth induced by urbanisation, and expansion of industrial / habitant area. Current infrastructure is not sufficient for disaster prevention, and institutional system, human resources, information system, etc. have challenges in disaster management. Capacity development in government, academia and industry is important for effective disaster management, as well as collaboration among these three players. Yangon Technological University (YTU) is designated as a Centre of Excellency (COE) by the Ministry of Science and Technology (MOST). Since in September 2012, YTU and the University of Tokyo have been collaborating in researches and education in the field of disaster management, including the provision of lectures, assistance of establishing the GIS and remote sensing laboratory, and collaborative survey and research in the Bago River Basin. Based on these activities, YTU and the University of Tokyo jointly constructed a project proposal to establish scenario analysis systems to assess Myanmar's future disaster vulnerability which will contribute to enhancement of disaster management capacity of the Republic of the Union of Myanmar.

4-2 Cooperation Strategy of the Government of Japan

Disaster Management is one of the components of the Country Assistance Policy for the Republic of the Union of Myanmar. One of the priory cooperation areas of the Country Assistance Policy is "Livelihood of the people", and disaster management is one of the components of this pillar.

5. Overall Goal and Project Purpose (from Record of Discussions(R/D))

(1) Overall Goal

YTU further utilizes the Collaboration Platform to contribute to the urban safety in Yangon and Bago.

(2) Project Purpose

YTU understands and develops a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety in Yangon and Bago.

6. Implementing Agency

- Department of Technology Promotion and Coordination (DTPC) as Co-Chair (Note: Due to the reform of government structures of Myanmar, Ministry of Education (MOE) has succeeded the role of Co-Chair from MOST since 2016 and DG of the Department of Higher Education (DOHE) of MOE became the responsible agency which was confirmed at the 3rd JCC meeting in 2017.)
- Yangon Technological University (YTU)
- Department of Disaster Management (DDM), Ministry of Social Welfare, Relief and Resettlement (MoSWRR)
- General Administration Department (GAD), Ministry of the Office of the Union Government
- Department of Meteorology and Hydrology (DMH), Ministry of Transport and Communication (MOTC)
- Public Works (PW), Ministry of Construction (MOC)
- Irrigation and Water Utilization Management Department (IWUMD), Ministry of Agriculture, Livestock and Irrigation (MOALI)
- Directorate of Water Resources and Improvement of River Systems (DWIR), MOTC
- Department of Hydropower Implementation (DHPI), Ministry of Electricity and Energy (MOEE)
- Department of Human Settlement and Housing Development (DHSHD), MOC
- Mandalay Technological University (MTU)
- Yangon City Development Committee (YCDC)
- Myanmar Engineering Society (MES)
- Myanmar Geo-Science Society (MGS)
- Myanmar Earthquake Committee (MEC)

II. Results of the Project

1. Results of the Project

1-1 Input by the Japanese side (Planned and Actual)

(1) Dispatch of Experts

The Japanese side assigned a total of 41 experts to the Project in six research groups, namely Water-related Disaster Group (total number of experts: 10), Infrastructure Group (10), Human Mobility and Transportation Group (7), RS/GIS Group (1), Earthquake-related Disaster Group (10) and Disaster Management Group (6 including 3 overlapping members with Earthquake-related Disaster Group). Experts travelled frequently to Yangon and its vicinity (mainly Bago region) to conduct research activities together with YTU and strategic partners. (See Annex 1-1)

(2) Number of Participants in the Trainings in Japan

The Japanese side conducted 10 trainings in Japan and a total of 34 officials participated during the Project period. (See Annex 1-2, 1-3)

(3) Provision of Equipment

The Japanese side provided various types of equipment for the Project. The total amount of the provided equipment is approximately 1,03,886,360 JPY. (See Annex 1-4)

(4) Cost of Operation

The Japanese side has input a total amount of 44,058,042 JPY for the operation of the project activities by the end of March 2020. This amount includes the expenses for labour cost of project staff, implementation of trainings, transportation, maintenance of equipment, consumables etc. (See Annex 1-5)

1-2 Input by the Myanmar side (Planned and Actual)

(1) Assignment of Counterparts

A Director General from MoST has served as the Project Director during the first period, then it has been changed to a DG from MoE due to an organizational change in Myanmar. The Project Director also served as the Chairperson of the Joint Coordination Committee (JCC), which meeting was held every year. Total of five JCC meetings were held during the Project period to review the progress of project activities, future plans and exchanged information and ideas among the participants. 40 to 60 people participated the JCC which consisted of various key stakeholders called "Strategic Partner" (SP) under the Project, including YTU, DoHE, DDM, DMH, PW, DUHD, IWUMD, DWIR, MOC, YCDC, and MEC of the Fed. Of MES.

From YTU, Project Manager was served by the rector, Research Head was served by the pro-rector and six faculty members were assigned to be counterpart leaders of each of six research groups. A total of 82 persons including YTU faculty members (31) and students (32) and officials from SP organizations (19) participated actively during the Project period. (See Annex 1-2 for JCC members)

(2) Provision of Project space, necessary equipment and expenses

Office space for the Project was provided in Technological Research Center (TRC) building inside YTU campus and utility including electricity, water and internet was paid by YTU.

(3) Other inputs

Strategic partners for the Water-related Disaster group provided both financial and technical support for the Project. In 2017, MOALI and IWUMD provided funding to construct water level observation tower in Tawa. In 2019, DWIR provided funding and MOC and PW provided technical support to implement water gauge in Dagon Bridge and also DHPI provided funding to implement water gauge at Zaung-Tu Dam.

1-3 Activities (Planned and Actual)

The project activities were implemented mostly as described in the PDM (PDM Ver.1) and its Plan of Operation (PO) without significant delay. Modification compared to the initial plan are described in “3. History of PDM Modification”. The planned and actual activities are shown in Table 1.

Table 1: Results of the Activities

Output 1: Development of physics model to evaluate disaster vulnerability	
Planned	Actual activities
Output 1-1. Develop hydrological and flood inundation model of study area	<ul style="list-style-type: none"> - Installation of water-related equipment (5 Automatic Weather Stations (AWS) and 3 Automatic Hydrological Monitoring Stations (AHS)) along the Bago River has been completed supported by collaborating organizations namely MOALI, IWUMD, DWIR, MOC PW and DHPI. Meteorological and hydrological data observed by using the equipment are archived at YTU server through telemetry system continuously. - An enhanced Digital Elevation Model (DEM) of the Bago River Basin was developed and high tide inundation model for the lower Bago River basin was developed to understand more accurate hydrological characteristics to be used for flood vulnerability assessment.
Output 1-2: Establish Earthquake vulnerability assessment method and create of Yangon digital map database	<ul style="list-style-type: none"> - Structural analysis of typical 2-story timber houses in Sanchaung Township (Feb 2019), a pull-down experiment of typical stilt houses in an informal settlement (Mar 2019) were conducted to evaluate seismic characteristics. - Fragility curves for normal timber structures, stilt houses, RC buildings, and Brick-nogging structures were developed. - Microtremor measurement has been conducted at 120 points in Yangon City (2018-2019) to acquire ground information and amplification factor map was created using acquired data including borehole data. - Urban Risk Monitoring System (URMS) was introduced to the Urban Planning Division (UPD) of YCDC (Dec 2016) in order to help monitor urban issues, evaluate the impact of new construction projects to the surrounding areas for disaster risk mitigation. Investigation was conducted with UPD to identify data location and some of the required data was acquired for pilot area (Dawpon Township and Kyauktada Township) to verify the data for URMS. An Urban Planning Workshop for Risk Monitoring was conducted at YTU and YCDC (Jan 2019) to share the result of verification using acquired data and hands-on GIS session “Road blockage analysis” was conducted at UPD and YTU. - Evaluation of urban functions for disaster response (analysis of current fire-fighting response capacity & coverage of evacuation space) was conducted. - A series of workshops “Re-Discover Yangon” (Total 4 times in Apr, May, June, Nov 2016) and “Workshop for structural evaluation of common timber housing and heritage timber building” (Total 5 times in Feb, June, Nov 2018, Feb, May 2019) were conducted with 3 objectives; capacity development, technology transfer and building of database) and help develop curriculum for YTU’s Architecture Department to cultivate human resources at YTU to

	<p>become future urban planners.</p> <ul style="list-style-type: none"> - “Urban Heritage Design Studio” was conducted as a part of the curriculum in collaboration with US Fulbright visiting scholar (2017). - Historical buildings surveyed during the Project was put together as a map. - An integrated digital map database is completed and built on WebGIS platform.
<p>Output 1-3: Development of urban development model in survey area</p>	<p>[RS/GIS Group]</p> <ul style="list-style-type: none"> - Urban development model has been created using topographical model and distribution of built-up areas estimated from satellite images. - Analysis and evaluation of existing infrastructure information such as buildings, bridges and railroads was carried out using 3D laser scanner and close-range photogrammetry. - Methods to extract building outlines and roads have been developed using Machine Learning algorithm. <p>[Transport and Human Mobility Group]</p> <ul style="list-style-type: none"> - Based on Call Detail Record (CDR) data (1-7 Dec. 2015) from MPT, following research activities were carried out to establish Big Data Processing Platforms: 1) Grid-square multi temporal population estimation, 2) OD (Origin–Destination) trip distributions, 3) OD route identification and 4) Geo-visualization of human mobility. - Several traffic congestion scenarios were calculated, depending on future traffic policy, such as lane capacity design and total traffic demand prediction. - Traffic monitoring is conducted on taxi and the movements have been recorded and survey of the behavior of public transportation such as buses were conducted. Using those data, relationships of a fare and a distance have been investigated in case of traditional taxis and on demand taxis. - A fixed point observation was carried out in response to a request from YRTA to extract the traffic flow at the road intersection and the number of cars automatically, with a cooperation of the Traffic Control Center.
Output 2: Development of scenario analysis system for assessing future disaster vulnerability	
Planned	Actual activities
<p>Output 2-1: Assess characteristics of water-related disaster vulnerability</p>	<ul style="list-style-type: none"> - Social and economic characteristics of the residents and the impact of flood on livelihood have been investigated in order to develop a method to evaluate vulnerability of Yangon City for water related disaster and the relationship between land use and social economy has been analyzed. - Flood damage functions have been developed by integrating the flood inundation map and the data from the questionnaire survey. - Flood inundation for historical and future events have been simulated using WEB-DHM model.

	<ul style="list-style-type: none"> - Based on tidal impact survey conducted, a method to evaluate low-frequency large-scale high tide disasters such as Cyclone Nargis was developed and evaluated the impact of the developed waterway network in the delta region on storm surges. - Atmospheric method was prepared to increase resolution of coarse resolution (~160km) global climate model output to high-resolution (~12km) past and future climate projections. - Expected inundation areas in the Bago River basin in case of Precipitation Return Period from 2 years, 100 years, and 500 years were simulated and demonstrated on "Bago River Near Real-time Inundation Analysis System."
<p>Output 2-2: Assess characteristics of earthquake disaster vulnerability and create earthquake vulnerability map</p>	<ul style="list-style-type: none"> - Distance based attenuation model was tested to estimate the intensity of ground shaking and possible scenario patterns with proper input and algorithm was examined. - Using the fragility curves and amplification maps created, earthquake disaster vulnerability was evaluated and 3 versions of integrated earthquake vulnerability maps were created in a sequence. - Evaluation of seismic resistance of timber structure was conducted to develop a method for preserving timber structure (2018). - Earthquake resistance of some of the historic building were assessed and distribution map was created. Making of a booklet to summarize the result of the survey for historical building was conducted.
<p>Output 3: Development of main roles and activities of research centre for urban safety in YTU to sustain and enhance research activities and human resource development</p>	
<p>Planned</p>	<p>Actual activities</p>
<p>Output 3-1: Develop activities in research centre for urban safety in YTU</p>	<ul style="list-style-type: none"> - YTU submitted MOE the proposal of a series of Research Centers (RCs), with the highest priority of RC for Urban Safety based on the draft developed by the project in August 2017. MOE officially approved establishment of RS/GIS RC first at YTU in December 2017 and an official opening ceremony was held in October 2018. - Since the RS/GIS RC was established earlier, it was agreed by the board members of the RC that the RS/GIS RC would take care of the roles of the RC for Urban Safety until its establishment. - Board members of the RC was discussed and YTU allocated new staffs to reinforce the activities of the RS/GIS RC. - A number of seminars, workshops and meetings for research activities and capacity development have been conducted using the RC. - Web GIS data base system has been developed and installed in the server of RC and a workshop was held to get feedback from the participants to improve the system and expand the database. - "Student seminar" was introduced and has been held once in two months at

	<p>the RC. This seminar has enhanced research and presentation skill of YTU researchers and also research guidance skill of YTU faculties.</p>
<p>Output 3-2: Develop educational program for government officials and graduate students as specialist of urban safety</p>	<ul style="list-style-type: none"> - Short term training courses and lectures, and OJT programs were prepared and proposed to be adopted by Myanmar partner organizations including YTU by each research group. - The Project assisted the development of YTU's curriculum especially for RS/GIS group and Earthquake-related disaster group (Heritage team). RS/GIS Group conducted lectures to graduate students as a part of existing curriculum in the Department of Electronics. - Heritage workshops were conducted as a part of field training program for the undergraduate in the Department of Architecture and the Project provided advice for a new curriculum in the Department of Architecture.
<p>Output 3-3: Develop consortium among government, academia, and industry</p>	<ul style="list-style-type: none"> - Six preliminary meetings (Dec 2016, Apr, Jul, 2017, Feb, Mar, Jul 2019) were held to introduce the idea of the Consortium, exchange ideas, share research outputs with YTU, Strategic partners and private companies. Feedback from these meetings organizations were used in the development of Article of Association (AoA) for the Consortium prepared in Sept. 2019. - "Seminar on Commencement of Activities of Consortium" was held in NPT on 1 Oct 2019, on the same day of the 5th JCC Meeting. Organization structure, constitution and future plan of the Consortium were introduced, and 3 systems developed through the Project were demonstrated. Feedback from the participants (IWUMD, DWIR, DUHD, DMH, MOC, MGS, MES, MEC and YCDC) were received after the meeting to confirm their willingness to participate and to finalize the AoA to submit to MOE. - Discussion for possible collaborative research projects have been conducted among YTU and the Japanese side in order to utilize the resources effectively and promote active exchange among related organizations in the Consortium. - In February 2020, YTU informed the Japanese side that the MOE requested the Japanese side to provide names of two signers to be included as Board members in an official document. After acquiring names from other concerned parties and if MOE would give a permission to establish the Consortium, a formal signing ceremony was supposed to be held at the end of March 2020 attended by a number of Japanese members. However the ceremony is postponed in mid-March due to the situation caused by COVID-19.
Output 4: Development of integrated disaster response support system including infrastructure maintenance management with adequate technologies	
Planned	Actual activities
<p>Output 4-1: Propose improved infrastructure management and maintenance system, and technology for</p>	<p>[Infrastructure management group]</p> <ul style="list-style-type: none"> - A simple system for monitoring deformation on bridge was installed and relative displacement between the girder and the abutment was measured with a displacement meter in case of PC Bridge in 2017. - A method for monitoring the inclination of bridge has been applied to Twantay Bridge in 2017 and result of the analysis of vibration measurement for Twan

<p>securing disaster mitigation function in Myanmar</p>	<p>Tay Bridge and Pathein Bridge was reported to MOC in February 2018.</p> <ul style="list-style-type: none"> - Maintenance system of infrastructures was surveyed by interview to MOC engineers and literature review. - The cause of the damages and structural performances were evaluated based on the results of monitoring, measurements, and FE simulation of damaged bridges in Yangon. - Non-destructive testing was applied to examine the quality of concrete of structures. - Participants of training course “Investigation of residual structural performance of damaged bridge in Myanmar and its monitoring” learned basic theory/knowledge of infrastructure management and structure, and the method of data analysis of bridge monitoring. - Applicability of load estimation by B-WIM was confirmed and it was found that measurement method should be devised depending on the structure. - Improved management and maintenance system has been proposed, inspection and monitoring method for infrastructures have been applied and proposed and a maintenance system has been applied and proposed to MOC. - Investigation on the cause of the bridge collapse accident in Myaung Mya in April 2018 and the safety survey of similar type of bridges were conducted. And as a result, an establishment of the maintenance scheme for cable bridges was proposed. - Field investigation using non-destructive test equipment for actual structures were conducted to promote the application of non-destructive tests to evaluate the performance of existing structures. In addition, bridge retrofit method was proposed to MOC based on the investigation of the damage level of Twantay bridge and Pathein bridge.
<p>Output 4-2: Develop integrated disaster response support system for Earthquake and Water-related disaster</p>	<p>[Water related disaster Group]</p> <ul style="list-style-type: none"> - “Bago River Near Real-time Inundation Analysis” was developed and it is under development on DIAS (Data Integration and Analysis System) platform. The test run was conducted from July to September 2019 among 5 Myanmar governmental departments namely IWUMD, DWIR, DMH, DHPI and YTU and based on their feedback, the system was improved and all the system development was completed in March 2020. - Technical meeting on satellite rainfall product (GSMaP) and Probablic Rainfall Density Evaluation, High-level meeting on Data Integration for Flood Risk Reduction was held in July 2019. - Needs and functions of the flood disaster forecast system were identified by conducting workshops with governmental officers while requirements of local residents about disaster information dissemination were clarified through interviews and questionnaire surveys. - 2-day training course on weather and hydro-meteorological data analysis using

	<p>DIAS was conducted for potential users of the system in February 2019 and 12 persons from 5 governmental organizations (DWIR, IWUMD, DMH, DDM and YTU) received the certificate.</p> <p>[Disaster Management Group]</p> <ul style="list-style-type: none"> - Disaster management plans and countermeasures of local and central governments in Myanmar were investigated by interviewing officers from DDM, YCDC, Red Cross and in 2017 and a flowchart of disaster response activities was completed. - Field survey in Chin State was conducted to investigate the actual disaster response activities. - Disaster Response Support System was completed based on the previous surveys and after discussing with YTU and trainings were conducted many times using the system to national governmental staffs including all directors of GAD in Myanmar at the GAD Training School and YCDC officers in 5 townships in CBD in 2019. - Earthquake Vulnerability Map was created (Output 2-2) and the result of the analysis using the map is supposed to be used for evaluating the damage to calculate the amount of support needed in response to disaster.
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2. Achievements of the Project

2-1 Outputs and indicators

(1) Output 1

All indicators for the Output 1 have been attained thus its achievement level is high.

Target values (Objectively Verifiable Indicators) and actual values (Achievement) are shown in Table 2.

Table 2: Achievement of Output 1

Output 1: Development of physics model to evaluate disaster vulnerability	
Objectively Verifiable Indicators	Achievement
1-1 Meteorological and hydrological observation of target areas, performance evaluation of structures, and capacity of people / traffic monitoring are improved and Hydrology and flood inundation model in research area is developed	<ul style="list-style-type: none"> - Installation of all planned equipment for the meteorological and hydrological observation is completed and the data has been archived in the YTU server. <p>As the indicator has been achieved 100%, achievement level is “High”.</p>
1-2 Earthquake vulnerability assessment method is established, and Yangon digital map database is created	<ul style="list-style-type: none"> - Fragility curves for normal timber structures, stilt houses, RC buildings, and Brick-nogging structures were constructed. - Amplification map was developed using the result of field survey and acquired data.

Output 1: Development of physics model to evaluate disaster vulnerability	
	<ul style="list-style-type: none"> - Final digital map is arranged by using all data. <p>As the indicator has been achieved 100%, achievement level is “High”.</p>
1-3 Urban development model in survey area is developed	<ul style="list-style-type: none"> - Urban development model has been created using topographical model and distribution of built-up areas estimated from satellite images. - Research and development issues using mobile CDR and GPS trajectory taxi data were investigated to understand human mobility patterns, trip distributions, travel behaviors and evaluated various taxi services that will help to solve current traffic congestion problems and effective emergency planning. <p>As the indicator has been achieved 100%, achievement level is “High”.</p>

(2) Output 2

All indicators for the Output 2 have been attained thus its achievement level is high.

Target values (Objectively Verifiable Indicators) and actual values (Achievement) are shown in Table 3.

Table 3: Achievement of Output 2

Output 2: Development of scenario analysis system for assessing future disaster vulnerability	
Objectively Verifiable Indicators	Achievement
2-1 Water-related disaster vulnerability is assessed	<ul style="list-style-type: none"> - Expected inundation areas in the Bago River basin in case of Precipitation Return Period from 2 years, 100 years, and 500 years were simulated and demonstrated on "Bago River Near Real-time Inundation Analysis System." - Social vulnerability of people residing in flood prone areas was assessed through household interview survey in Bago. <p>As the indicator has been achieved 100%, achievement level is “High”.</p>
2-2 Earthquake-related disaster vulnerability is assessed Earthquake vulnerability map is created	<ul style="list-style-type: none"> - Version 3 of the Earthquake vulnerability map has been completed. <p>As the indicator has been achieved 100%, achievement level is “High”</p>

(3) Output 3

All indicators for the Output 3 have been attained thus its achievement level is high.

Target values (Objectively Verifiable Indicators) and actual values (Achievement) are shown in Table 4.

Table 4: Achievement of Output 3

Output 3: Development of main roles and activities of research centre for urban safety in YTU to sustain and enhance research activities and human resource development	
Objectively Verifiable Indicators	Achievement
3-1 Framework of research centre for urban safety is developed in YTU	<ul style="list-style-type: none"> - Research center is actively used for various research activities. - YTU RS/GIS Research Center conducted joint workshop with MTU to help establish strong network and promote research collaboration <p>As the indicator has been achieved 100%, achievement level is “High”.</p>
3-2 Educational program to foster specialized persons is developed	<ul style="list-style-type: none"> - Joint lectures and workshops were developed and conducted by both Myanmar and Japanese members of RS/GIS G and Earthquake-related disaster Group (Heritage Team) as a part of existing curriculum. <p>As the indicator has been achieved for some departments but not all, achievement level is “Moderate”. (see 3-2 of Table 1)</p>
3-3 Basic concept of Consortium among government, academia, and industry is developed in YTU through trial activities	<ul style="list-style-type: none"> - Seminar on Commencement of Activities of Consortium was held and Organization structure, Constitution and future plan of the Consortium were introduced with CPs and SPs. - All necessary actions are taken by the Project in order to establish the Consortium. - In February 2020, YTU informed the Japanese side that the MOE would formally authorize the establishment of the Consortium and requested the Japanese side to provide names of two signers to be included as Board members in an official document. After acquiring names from other concerned parties, a formal signing ceremony was supposed to be held at the end of March 2020 attended by a number of Japanese members. However the ceremony is postponed in mid-March due to the situation caused by COVID-19. <p>As the indicator has been achieved partially, achievement level is “Moderate”.</p>

(4) Output 4

All indicators for the Output 4 have been attained thus its achievement level is high.

Target values (Objectively Verifiable Indicators) and actual values (Achievement) are shown in Table 5.

Table 5: Achievement of Output 4

Output 4: Development of integrated disaster response support system including infrastructure maintenance management with adequate technologies	
Objectively Verifiable Indicators	Achievement
4-1 Improved infrastructure management and maintenance system, and technology for securing disaster mitigation function in Myanmar is proposed	<p>[Infrastructure management group]</p> <ul style="list-style-type: none"> - A new JICA project for technical transfer for road and bridge maintenance is formulated based on the output from the Project and the project leader prepared a detailed plan in collaboration with MOC, YTU and Japanese organizations. In the next project, the equipment donated for the Project will continued to be used. - Research for infrastructure management will be continued with a new research fund by Japan Society of Civil Engineers (JSCE) for an application of non-destructive inspection and monitoring technology in Myanmar and human resource development. <p>As the indicator has been achieved 100%, achievement level is “High”.</p>
4-2 Integrated disaster response support system is developed	<p>[Water-related disaster group]</p> <ul style="list-style-type: none"> - Trial run of the "Bago River monitoring and flood simulation system" was conducted and based on the feedback, the system was modified for improvement. <p>[Disaster management group]</p> <ul style="list-style-type: none"> - Trainings using the Disaster management support system were conducted at city government office and YTU. <p>As the indicator has been achieved 100%, achievement level is “High”.</p>

2-2 Project Purpose and indicators

The achievement level for the Project Purpose is high as its indicators have been achieved. Three main indicators are 1. Publishing of papers, 2. Issuing of policy related reports and 3. Developing of systems.

1. The Project aimed at publishing at least 20 peer reviewed research papers to international journals written by mainly YTU (meaning the first author is from YTU) and as a result 23 peer reviewed research publications (19 peer reviewed research papers and 4 peer reviewed survey reports/notes) whose first authors are YTU researchers were published as of March 2020. The Project published Special Issue on SATRES Myanmar Project with Journal of Disaster Research (JDR) twice during the Project period, the first issue (Vol.13, No.1) in FY2017 and the second issue (Vol.15, No.3) in FY2019 which compiled research outcomes from the Project and a total of 37 peer reviewed publications, 16 (12 research papers, 2 survey reports and 2 notes) by mainly YTU and 21 (17 research papers, 1 survey report and 3 notes) by mainly Japanese side, were included in the two special issues with JDR. A total of 54 peer reviewed papers were published by international journals and 10 peer reviewed papers were published by domestic (Japanese) journals during the Project period. (See Annex 2-1)

2. During the Project period, two disasters related to our project occurred in Myanmar. One was a collapse of Myaung Mya Bridge in Ayeyarwady Region on 1st April 2018, and the other was monsoon seasonal flood triggered by heavy rains which affected large area in Southeastern part of Myanmar including Bago region in summer 2018. Infrastructure Group contributed by providing support immediately after the bridge collapse and worked closely with Myanmar Government, mainly with the Ministry of Construction, Japanese Government and private sectors to respond to the emergency needs and three summary reports were submitted to the Government of Myanmar.

In response to the flood disaster in Bago region, Water-related Disaster Group contributed by operating the Near Real-time Inundation Analysis System which was in its development phase in order to provide real time data such as area of inundation, water level and rainfall condition to 4 departments of Myanmar Government. The group collaborated with researchers from SATREPS RS/GIS group, The University of Tokyo, Tohoku University and YTU with a support from JAXA and AIT, analyzed the data collected and finally compiled two reports and submitted to the Government of Myanmar in August 2018. The group also conducted field surveys of affected communities to understand the damage level and affected population. (See Annex 2-2)

3. Infrastructure Group, Water-related Disaster Group, Human Mobility and Transportation Group and Disaster Management Group developed systems, respectively. (See Annex 2-3)

Capacity of YTU faculty members and students have been enhanced greatly in terms of carrying out and supervision of research activities during the Project as indicated in the number of published research papers. A total of 20 students from Myanmar have acquired degree (8 PhD, 12 Master) during the Project working together with Japanese researchers. Given the fact that many of them did not have sufficient experience of research activities before the Project began, these are notable achievements of the Project. (See Annex 2-4)

Target values (Objectively Verifiable Indicators) and actual values (Achievement) are shown in Table 6.

Table 6: Achievement of the Project Purpose

Project Purpose: YTU understands and develops a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety in Yangon and Bago	
Objectively Verifiable Indicators	Achievement
1 At least 20 research papers related to the project, which are submitted by mainly YTU during the project period, are accepted by international journals	<p>A total of 23 peer reviewed research publications (19 peer reviewed research papers and 4 peer reviewed notes/survey reports) related to the project prepared by mainly YTU (meaning main author is from YTU) were accepted and published by international journals by March 2020.</p> <p>A total of 31 peer reviewed research publications (27 peer reviewed research papers and 4 peer reviewed notes/survey reports) related to the project prepared by mainly Japanese side were accepted and published by international journals by March 2020.</p> <p>Also, a total of 10 peer reviewed research papers prepared by Japanese side were published by domestic (Japanese) journals by March 2020.</p> <p>A total of 64 peer reviewed research publications (54 international journal / 10 Japanese journal) were published during the project period.</p>

Project Purpose: YTU understands and develops a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety in Yangon and Bago	
	As the indicator has been achieved by 115%, achievement level is “High”.
2 Some suggestions, advises and policy proposals by using the Comprehensive Disaster Resilience System are submitted to relevant governments.	<p>A total of 5 policy related documents were submitted and policy recommendations were made. (See Annex 2-2)</p> <p>[Infrastructure management group]</p> <ul style="list-style-type: none"> - A report of the investigation of the collapse of Myaung Mya Bridge was submitted to MOC in 2018. - A report of the safety investigation of cable-type suspension bridges was submitted to MOC in 2018 to help improve safety investigation and maintenance works for similar type of bridges in Myanmar. - A policy recommendation was made to establish a regulation for cable-type bridges such as periodical inspection to MOC in 2018. <p>[Water-related disaster group]</p> <ul style="list-style-type: none"> - A flood-control plan and urban development plan in Bago were presented to DMN, DWIR, IWUMD and DDM using the result of assessing water-related disaster vulnerability in the Bago River Basin in 2018. - A summary report of the 2018 Myanmar flood response including data analysis was submitted to DMH, DWIR, IWUMD, DHPI and DDM in August 2018 using the Near Real-time flood inundation simulation system developed by the Project. - As the indicator has been achieved by 100%, achievement level is “High”.
3 The Comprehensive Disaster Resilience System is developed and under operations by YTU	<p>[Infrastructure group]</p> <ul style="list-style-type: none"> - Monitoring system of bridges were developed and presented to MOC. <p>[Water-related disaster group]</p> <ul style="list-style-type: none"> - “Near Real-time floor inundation simulation system” is completed and handed over to YTU for operation. <p>[Transportation and Human Mobility group]</p> <ul style="list-style-type: none"> - “City Geospatial Dashboard” is completed and handed over to YTU for operation. - “Myanmar G-Spatial Information Dashboard” is

Project Purpose: YTU understands and develops a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety in Yangon and Bago	
	<p>completed and handed over to YTU for operation.</p> <p>[Disaster Management group]</p> <ul style="list-style-type: none"> - “Disaster Response Support System” is completed and handed over to YTU for operation. <p>As the indicator has been achieved by 100%, achievement level is “High”.</p>

3. History of PDM Modification

3-1 PDM Ver.0 (Approved in April 2015)

Based on the result of discussion during the project preparation period, the PDM Ver. 0 was developed.

3-2 PDM Ver. 1 (Approved in November 2017)

A total of 55 amendments were made to the PDM once during the Project. Additional activities with more details were added in response to a recommendation by JICA to include activities which are conducted but not mentioned in PDM. See Table 7 for a list of all the modifications made.

Overall Goal and Project purpose (no.1-6, Table 7) were modified to emphasize “Collaboration Platform” and “Comprehensive Disaster Resilience System” and also to include Yangon and Bago as target areas and Objectively Verifiable Indicators (OVI) and Means of Verification (MOV) was modified to set more specific goal such as number of proposals and certified persons trained by the Project.

Output 1 was modified to be more specific and include details (no.7-9) but for Output 3 (no.10-13) concerning the establishment of a Research Center (RC) and the Consortium, expression was modified as the Project faced a difficulty of achieving the objectives stated in the PDM due to a lack of autonomy of YTU. For Output 4 (no.14-16), development of “integrated disaster response system” was changed to “integrated disaster response support system” by adding a word “support” to clarify that the output to be used as a training tool rather than as a real-time system to be used during the disaster.

Regarding “activities”, 39 activities are modified with more details and 22 are newly added in order to include all conducted activities under the Project in the PDM.

Table 7: Amendments to PDM

PDM Modification			
No.	Item	Before	After
1	Overall goal	YTU further develops the scenario analysis systems by its Research Centre for Urban Safety	YTU further utilizes the Collaboration Platform to contribute to the urban safety in Yangon and Bago
2	Objectively Verifiable Indicators (OVI) for Overall goal	At least 1 suggestion based on the result of the updated scenario analysis is submitted to relevant governmental departments mainly by YTU’s Research Centre for Urban Safety	<ol style="list-style-type: none"> 1. At least 4 policy proposals on the result of the Comprehensive Disaster Resilience System are made for relevant governments by YTU team 2. At least 20 specialized persons in urban safety sector are trained at in YTU
3	Means of	1. Updated and improved	1. Number of proposals made by YTU team

PDM Modification			
No.	Item	Before	After
	Verification (MOV) for Overall goal	database 2. Documents submitted	2. Number of certified specialized persons trained by YTU
4	Project purpose	YTU understands in use of scenario analysis systems to assess Myanmar's future disaster vulnerability	YTU understands and develops a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety in Yangon and Bago
5	OVI for Project purpose	2. Suggestions based on the result of the scenario analysis and submitted to relevant governmental departments	2. Some suggestions, advises and policy proposals by using the Comprehensive Disaster Resilience System are submitted to relevant governments.
6	OVI for Project purpose	NA	3. The Comprehensive Disaster Resilience System is developed and under operations by YTU
7	Outputs 1-1	Recent flood events simulated by the developed hydrological and hydraulic model	Meteorological and hydrological observation of target areas, performance evaluation of structures, and capacity of people / traffic monitoring are improved and Hydrology and flood inundation model in research area is developed
8	Output 1-2	Building damage grade estimated at certain earthquake	Earthquake vulnerability assessment method is established Yangon digital map database is created
9	Output 1-3	Daily people movement simulated by the model	Urban development model in survey area is developed
10	Output 3	Support to establish Research Centre for Urban Safety in YTU to sustain and enhance research activities and human resource development	<u>Development</u> of main roles and activities of research centre for urban safety in YTU to sustain and enhance research activities and human resource development
11	Output 3-1	<u>Establishment</u> of Research Centre for Urban Safety in YTU	Framework of research centre for urban safety is <u>developed</u> in YTU
12	Output 3-2	Educational program to foster specialists	Educational program to foster specialized persons is developed
13	Output 3-3	<u>Establishment</u> of consortium among government, academia, and industry	Basic concept of Consortium among government, academia, and industry is <u>developed</u> in YTU through trial activities
14	Output 4	Development of integrated disaster response system including infrastructure maintenance management with adequate technologies	<u>Development</u> of integrated disaster response <u>support</u> system including infrastructure maintenance management with adequate technologies

PDM Modification			
No.	Item	Before	After
15	Output 4-1	Tutorial for integrated disaster response system	Improved infrastructure management and maintenance system, and technology for securing disaster mitigation function in Myanmar is proposed
16	Output 4-2	Guideline proposed on improved infrastructure management and maintenance system	Integrated disaster response support system is developed
17	Activities 1-1-1	Gather information and data in river, hydro-climate and water resource management and build integrated database	Collect information and data in meteorology, hydrology, and water resource management and build database
18	Activities 1-2-1	Collect land use, population, buildings, infrastructures, and topographical information in study area	Investigate damage by past earthquakes in Myanmar
19	Activities 1-2-2	Investigate damage by past earthquakes in Myanmar	Develop an earthquake vulnerability evaluation model (understanding building characteristics and developing of seismic fragility function) from the viewpoint of building characteristics in Yangon
20	Activities 1-2-3	NA	Construct vulnerability assessment model based on the ground characteristics (including topographic information) in Yangon
21	Activities 1-2-4	NA	Establish disaster vulnerability assessment model from Yangon's regional urban functions based on the performance and distribution survey of important facilities in case of disaster
22	Activities 1-2-5	NA	Survey on distribution and characteristics of historic buildings in Yangon
23	Activities 1-2-6	NA	Create integrated digital map database
24	Activities 1-3-1	Analyse collected geo-spatial data and develop urban expansion simulation by cellular automaton model	Collect and analyze geo-spatial data and develop urban expansion simulation
25	Activities 1-3-2	Collect and accumulate aggregated mobile phone base station usage data and probe vehicle GPS data	Collect data and predict traffic and people movement with people activity model
26	Activities 1-3-3	Project traffic and people movement with people activity model	(deleted)
27	Activities 2-1-1	Conduct climate change analysis in local scale	Analyze climate change impact in local scale

PDM Modification			
No.	Item	Before	After
28	Activities 2-1-3	Assess river runoff and vulnerability to water-related disasters based on scenarios with climate change and urban development	Assess river runoff and inundation hazard considering tidal effect
29	Activities 2-1-4	NA	Generate flood inundation map considering tidal effect
30	Activities 2-1-5	NA	Evaluate water-related disaster vulnerability based on scenarios with climate change and urban development
31	Activities 2-2-3	NA	Create earthquake ground motion map based on ground property evaluation
32	Activities 2-2-4	NA	Create building damage prediction map
33	Activities 2-2-5	NA	Create evaluation map of disaster response of urban function
34	Activities 2-2-6	NA	Assess earthquake resistance of historic building for preservation and create distribution map
35	Activities 2-2-7	NA	Evaluate earthquake disaster vulnerability and create integrated earthquake vulnerability map
36	Activities 3-1-1	NA	Make proposal and road map of research center
37	Activities 3-1-2	NA	Take necessary procedures for establishing research center
38	Activities 3-1-3	NA	Manage and operate research center before and after official launch including trial period
39	Activities 3-1-4	NA	Install integrated digital map database at research center
40	Activities 3-1-5	NA	Conduct seminars, workshops and meetings for research activities and further development of research center
41	Activities 3-2-2	Introduce YTU's education program	Propose trial lectures and curriculums to YTU education program
42	Activities 3-2-3	NA	Implement and verify educational program jointly by Japanese and YTU faculty members
43	Activities 3-2-4	NA	Implement educational program mainly by YTU faculty members and support revision of education program
44	Activities 3-3-1	Coordinate functions with MES	Identify expected roles and activities of consortium and formulating road map
45	Activities 3-3-2	Identify expected role of consortium	Study research output and potential external partners
46	Activities 3-3-3	NA	Prepare main tasks for operation

PDM Modification			
No.	Item	Before	After
47	Activities 3-3-4	NA	Conduct a couple of trial collaborative research activities for improvement of management / operation capacity
48	Activities 4-1-1	Analyse disaster management plan of central government and investigate needs on the system	Collect data, review management and maintenance system, and technology of Infrastructures, especially bridges, in Myanmar
49	Activities 4-1-2	Analyse disaster management plan of local government and investigate citizens' needs on disaster information	Propose improved management and maintenance system
50	Activities 4-1-3	NA	Apply and propose inspection and monitoring method for infrastructures and buildings with adequate retrofit technology for damaged infrastructure
51	Activities 4-1-4	NA	Propose adequate retrofit technology for vulnerable buildings including those with historic value
52	Activities 4-2-1	Review management and maintenance system, and technology of Infrastructures, especially road and bridges, in Myanmar	Survey and analyze disaster management plan of local & central government
53	Activities 4-2-2	Propose improved management and maintenance system	Analyze requirement of functions and needs of users for disaster response system
54	Activities 4-2-3	Apply and propose inspection and monitoring method for infrastructures and buildings with adequate retrofit technology for damaged infrastructure	Develop a prototype of support system for hazard assessment
55	Activities 4-2-4	Disseminate technology information	Introduce support system to research center in YTU and conduct training for YTU faculty members and potential users

4. Others

4-1 Results of Environmental and Social Considerations (if applicable)

Not applicable.

4-2 Results of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

Not applicable.