

**Republic of the Union of Myanmar
Ministry of Education**

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

APRIL 2020

**JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)**

The Project Completion Report

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

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Title: Project Director

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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))

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 Ayeyawardy 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.

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 priority 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	- Installation of water-related equipment (5 Automatic Weather Stations (AWS) and 3 Automatic Hydrological Monitoring Stations

<p>hydrological and flood inundation model of study area</p>	<p>(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.</p> <ul style="list-style-type: none"> - 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.
<p>Output 1-2: Establish Earthquake vulnerability assessment method and create of Yangon digital map database</p>	<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 become future urban planners. - “Urban Heritage Design Studio” was conducted as a part of the

	<p>curriculum in collaboration with US Fulbright visiting scholar (2017).</p> <ul style="list-style-type: none"> - 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.
<p>Output 2: Development of scenario analysis system for assessing future disaster vulnerability</p>	
<p>Planned</p>	<p>Actual activities</p>
<p>Output 2-1: Assess characteristics of water-related</p>	<ul style="list-style-type: none"> - Social and economical 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

<p>disaster vulnerability</p>	<p>social economy has been analyzed.</p> <ul style="list-style-type: none"> - 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. - 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

	<p>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.</p> <ul style="list-style-type: none"> - 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 the RC. This seminar has enhanced research and presentation skill of YTU researchers and also research guidance skill of YTU faculties..
<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.

	<ul style="list-style-type: none"> - 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 securing disaster mitigation function in Myanmar</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 Tay Bridge and Pathein Bridge was reported to MOC in February 2018. - 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

	<p>been applied and proposed to MOC.</p> <ul style="list-style-type: none"> - 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 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>[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

	<p>staffs including all directors of GAD in Myanmar at the GAD Training School and YCDC officers in 5 townships in CBD in 2019.</p> <ul style="list-style-type: none"> - 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. - 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

	<p>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> <p>As the indicator has been achieved 100%, achievement level is "High".</p>
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(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	<ul style="list-style-type: none"> - Version 3 of the Earthquake vulnerability map has been completed.
Earthquake vulnerability map is created	<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
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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 Ayeyawady 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> <p>As the indicator has been achieved by 115%, achievement level is "High".</p>
2 Some suggestions, advises and policy proposals by using the Comprehensive Disaster Resilience System are submitted to relevant	<p>A total of 5 policy related documents were submitted and policy recommendations were made. (See Annex 2-2)</p> <p>[Infrastructure management group] - A report of the investigation of the collapse of</p>

<p>governments.</p>	<p>Myaung Mya Bridge was submitted to MOC in 2018.</p> <ul style="list-style-type: none"> - 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”.
<p>3 The Comprehensive Disaster Resilience System is developed and under operations by YTU</p>	<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 completed and handed over to YTU for operation. <p>[Disaster Management group]</p>

	<p>- “Disaster Response Support System” is completed and handed over to YTU for operation.</p> <p>As the indicator has been achieved by 100%, achievement level is “High”.</p>
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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"> At least 4 policy proposals on the result of the Comprehensive Disaster Resilience System are made for relevant governments by YTU team At least 20 specialized persons in urban safety sector are trained at in YTU
3	Means of Verification (MOV) for Overall goal	<ol style="list-style-type: none"> Updated and improved database Documents submitted 	<ol style="list-style-type: none"> Number of proposals made by YTU team 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	<ol style="list-style-type: none"> Suggestions based on the result of the scenario analysis and submitted to relevant governmental departments 	<ol style="list-style-type: none"> Some suggestions, advises and policy proposals by using the Comprehensive Disaster Resilience System are submitted to relevant governments.
6	OVI for Project purpose	NA	<ol style="list-style-type: none"> 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	<u>Development</u> of main roles and activities of research centre for urban safety in YTU to sustain and enhance

		and enhance research activities and human resource development	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	Development of integrated disaster response <u>support</u> system including infrastructure maintenance management with adequate technologies
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
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
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.

III. Results of Joint Review

Terminal Evaluation of the Project was conducted from September 11 to October 1, 2019 to 1) confirm the achievements of the Project, 2) evaluate the Project based on five DAC Evaluation Criteria, 3) identify factors promoting / inhibiting project effects, and 4) give recommendations to the Project during the remaining project period as well as after the project completion.

The evaluation was conducted by the Evaluation Team (hereafter called the Team) which consisted of five Japanese and one Myanmar namely 1) Mr. Nobuo Iwai, Senior Representative from JICA Myanmar Office as a Team Leader, 2) Mr. Wataru Ono, Deputy Director, Disaster Risk Reduction Team 1, Disaster Risk Reduction Group, Global Environment Department of JICA as an Evaluation Planner, 3) Dr. Kaoru Takara, Dean of Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University as a Senior Researcher, 4) Mr. Kazuo Anazawa from JST as an Observer, 5) Ms. Ayako Namura, a Consultant from Tekizaitekisho, LLC as an Evaluation Analyst and 6) Ms. New Ni, Deputy Director General, Department of Higher Education, Ministry of Education as an Evaluator.

1. Results of Review based on DAC Evaluation Criteria

1-1 Relevance

The relevance of the Project is assessed as high based on the following facts and findings of the Team.

Consistency with the policies of the Government of Myanmar

Myanmar Sustainable Development Plan 2018-2030 issued in August 2018 provides a long-term vision of a peaceful, prosperous and democratic country. It is structured around three pillars, five goals, 28 strategies and 251 action plans to realize this vision. Under “Goal 5: Natural Resources and the Environment for Posterity of the Nation”, the strategy of reducing exposure to disaster is addressed as “Strategy 5.2: Increase climate change resilience, reduce exposure to disasters and shocks while protecting livelihoods, and facilitate a shift to a low-carbon growth pathway”. Myanmar Action Plan on Disaster Risk Reduction 2017, which set an overall target for 2030 and a comprehensive and unified action plan for disaster risk reduction with prioritized interventions across Myanmar until 2020. The plans have four Pillars including 1) assessment of disaster risk, 2) strengthening disaster risk governance, 3) mainstreaming disaster risk reduction, and 4) enhancing disaster preparedness. Therefore, the Project is highly aligned with the policy and plan of the Government of Myanmar.

Consistency with the policies of the Government of Japan

The Project is in line with the policies of the Government of Japan. Japan, in April 2012, addressed three pillars to assist Myanmar in: 1) improvement of the living standard of the people, 2) institutional development and capacity development of human resources that would contribute to the social and economic development, and 3) development of infrastructure and systems that enable sustainable development of the country. The Project corresponds to the policy of all pillars from the perspective of disaster risk reduction. The cooperation program between Japan and Myanmar issued in November 2016 identifies that nine pillars, one of which focuses on long-term and orderly urban development, disaster-related measures and housing and urban transportation. In this regard, the Project, which aims to establish a disaster resilience system and collaboration platform, is aligned with the policies of the Government of Japan.

Alignment with the Sendai Framework for Disaster Risk Reduction 2015-2030

The Sendai Framework for Disaster Risk Reduction 2015 -2030 adapted on 18 March 2015 calls for focused action within and across sectors in the four priority areas. The Project can contribute to all of the four priorities by developing a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety Yangon and Bago.

Priorities for Action in the Sendai Framework for Disaster Risk Reduction 2015 -2030

Priority 1: Understanding disaster risk.

Priority 2: Strengthening disaster risk governance to manage disaster risk.

Priority 3: Investing in disaster risk reduction for resilience.

Priority 4: Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction.

Consistency with needs of the Myanmar target groups and Appropriateness of project approaches

Myanmar has experienced severe disasters such as cyclones, storm and floods, as shown in the table below. Also, the large active fault called Sagaing Fault runs in the middle of the country and caused an earthquake in November 2012. To respond and be prepared well to/for a natural disaster, Myanmar had strong needs of applying science and developing technology to grasp a disaster and assess the vulnerability. In this respect, the Project’s objective of developing a disaster resilient system and a collaborative platform for urban safety responds to the needs of the Myanmar people.

Date	Disaster and affected areas	Causalities and damages
August 2019	Landslide Mon State	73 Casualties at Malat Thauung Landslides. Besides, the road link between Maulamyang and Dawei was severely damaged around Ye Township.
August 2018	Floods in Bago	Over 152,000 people evacuated, which leads emergency relief operation by Japan/ JICA
July 2018	Floods in Bago, Karen, Mon, Nay Pyi Taw, Tanintharyi, Magway, Sagaing, Ayeyarwady, Kayin	16 deaths, 109,659 people affected
July-August 2015	Severe landslides in Chin State, and floods particularly in Sagaing Region, Ayeyarwady Region and Magway Region	around 160,000 and 110 causalities
August 2014	Floods in Bago Region	15,850 people evacuated
August 2013	Monsoon floods in Kayin, Mon, Tanintharyi and Rakhine State and the Ayeyarwaddy	38,316 people displaced
November 2012	Earthquake in Sagaing	M 6.8, 13 death
August 2012	Whole country	Several thousand people displaced in Kayin State
October 2011	Floods in Magway	161 death, 30,000 people affected
August 2011	Floods in Bago	23,097 houses affected, 55,489 people affected
March 2011	Earthquake along the border with Thailand	M 6.8, 74 death
October 2010	Cyclone Giri, Rakhine State	45 death or missing 101,923 people remained homeless

Source: EM-DAT, International Disaster Database, Center for Research on the Epidemiology of Disaster – CRED (<https://www.emdat.be/index.php>) and JICA Myanmar Office

Appropriateness of selection of target counterpart

The Team concluded that the selection of target counterpart was appropriate since YTU is a top university in a country and specialized in technology and science. Setting the relevant agencies as Strategic Partners were significantly appropriate since the Project needed to have good cooperation with them in terms of sharing the observational data or existing data necessary for research activities and get them involved in the project activities since they were the primary users of the system which the Project developed.

1-2 Effectiveness

The effectiveness of the Project is assessed as relatively high.

Prospect of achieving the project purpose

The Team concluded that the Project has been effective for YTU to understand and develop a Comprehensive Disaster Resilience System and a Collaboration Platform for urban safety in Yangon and Bago to a great extent. The Project provided YTU teachers with opportunity of exposing world-class research activities and cutting-edge technology, and this has brought

their research capacity up dramatically. Now, YTU is recognized as the most advanced university in the field of disaster risk reduction.

Concerning a Collaboration Platform for urban safety, the Project was successful in establishing RS/GIS RC and has carried out some activities such as providing the classes of remote sensing at YTU and developing various digitalized maps with cooperation of other groups. Another Collaboration Platform for urban safety, namely the Consortium, is still underway to its official establishment and has not functioned yet as of the terminal evaluation. This is because the concept of Consortium, which is a collaborative framework among government, academia and industry, is entirely new in Myanmar and it takes time to obtain the approval of the Government of Myanmar. Considering these aspects, the Project generated a maximum result of establishing the Consortium.

As for the Comprehensive Disaster Resilience System, the Project needs to focus on some activities to ensure that the Strategic Partners can operate it. These include the localization of the Disaster Management Support System and the preparation of its manual in Myanmar language to promote its usage at the local authorities. Since YTU has the plan to provide more intensive training on this system, this will also ensure the good operation of the system.

Factors contributing to the achievement of project purpose

The factors contributing to the achievement of project purpose are examined as follows.

- In the Water-related Disaster Group, the Japanese researchers, YTU counterparts and Strategic Partners such as DMH, DWIR, IWUMD and DDM have good collaboration and motivation toward the enhancement of infrastructure management and technology and monitoring system, which contributed to bringing good results of research activities.

Logic from Outputs to Project Purpose

Achievement of outputs certainly will lead to the accomplishment of Project Purpose since the components necessary for development of a Comprehensive Disaster Resilience System and a Collaboration Platform were designed as the four outputs: collection of existing data and measurement of observational data, and development of models (Output 1), development of scenario analysis and assessment of future vulnerability (Output 2), development of a platform for research such as RC and Consortium (Output 3) and development of the integrated disaster response support system (Output 4). The Project is likely to achieve the four Outputs set in PDM and this will certainly lead to achieving the Project Purpose.

To date, no external factors affecting the project effectiveness have been observed, including the important assumption¹ which is defined in the PDM.

1-3 Efficiency

The efficiency of the Project is assessed as moderate.

All planned outputs will be likely to reach the targets. Since the Project mostly utilizes the existing basic systems such as DIAS and Disaster Management Support System which Japanese municipalities already utilize, the Project did not have to develop a system from the beginning and saved the budget for system development. On the other hand, the activities mainly related to the data collection activities and establishment of the Consortium, have to be extended. With regard to data acquisition necessary for developing various models and systems, it took longer time due to the difficulties in finding good quality of data in terms of both quality and quantity in Myanmar: in other words, difficulties were 1) uncertainty of data availability, 2) lower reliability of data, and 3) a lengthy administrative procedure to obtain approval for data sharing from other agencies.

In general, most of the project inputs have been appropriately delivered in terms of quantity and quality and in a timely manner and utilized for project activities and generating outputs. However, some issues on equipment provided were found as follows;

- 1) The 50 sets of GPS, which was initially installed to the public buses to monitor the movement of public transportation but taken off due to the restructuring of the bus routes in Yangon in 2017, have not been utilized by YTU. At this moment, the Project is considering alternative utilization of GPS.
- 2) The analysis software of microtremor procured through the Project runs in only Japanese. Although the Project prepared the English manual for YTU for major functions, the full function of this software cannot be utilized at YTU. The Project, currently, asked the company to localize the analysis software into English. It is expected that this will promote the utilization of microtremor.
- 3) The manuals of some of the equipment provided are only available in Japanese. The Project is currently compiling the list of equipment including detailed information of name, purpose, stored place, availability of manuals, and contact of equipment and identifying the equipment, for which the English manual should be prepared. This will promote the

¹ The PDM defines the important assumption toward the Project Purpose: "research center for urban safety is officially established under the responsibility of YTU during the cooperation period".

utilization of equipment and maintenance based on the compiled information.

Another factor interfering with project efficiency is the allocation of JICA expert and counterpart personnel. Concerning allocation of JICA expert, the position of a project coordinator was vacant for the first year. Due to this, YTU had to manage many administrative procedures with JICA including the procurement process of equipment. This was a heavy burden for YTU and limited the smooth disbursement of the project budget. With regard to the assignment of counterpart, the group leader of Infrastructure/Earthquake-related Disaster left the Project to participate to PhD program in Japan and the counterparts assigned for Infrastructure Group afterwards did not have sufficient background and motivation of/toward infrastructure management. This degraded the effective technology transfer in this field to YTU counterparts. Also, in the first half of the project term, the discussion on research activities was not promoted as expected since YTU teachers had less experience in doing research activities compared with the Japanese researchers. Although this situation has been gradually changed, particularly in the latter half of the project term, it adversely affected project efficiency.

1-4 Impact

There is a possibility to generate the impact of the Project in the future if some conditions described below are satisfied.

Prospects of Achieving the Overall Goal and utilization of research outcomes

If YTU continues and upgrades the research activities after the Project ends, there is a possibility to achieve the Overall Goal. For continued research activities at YTU, the issue to secure the research funds is one of the crucial issues (for more details, see “1-5 Sustainability”) meaning whether project impact is significantly generated depends on the financial issue. In this term, it is vital that the Consortium is firmly established and its research activities through the Consortium are very active. This will certainly create a virtuous cycle for research activities. It is also likely that the Consortium is a good channel not only to obtain research funds but also to strengthen the relationship with government and industry, users (customers) of research outcomes and to grasp the needs of users. Since the Consortium, which the Project supports its establishment, is a first collaborative framework among government, academia and industry in Myanmar, it may bring an impact to promote such collaborative framework in Myanmar in the future. Also, it is expected that the Consortium will contribute to enhancement of the YTU's role and function as the research institute.

Another important issue is the continued enhancement of research capacity of YTU. While the Project was effective to enhancing YTU's research capacity, further external assistance to enhance research capacity consciously is needed to generate project impact.

Other impacts

The RS/GIS RC provided the training to teachers of other universities who are interested in remote sensing in October 2018 and YTU has a plan to offer it annually. According to YTU, this is the national university's responsibility of raising the whole level of capacity of teachers in Myanmar. In this respect, the project effects will be extended to other universities. YTU has also conducted the research of damage from a landslide in Chin State apply what they have learned through the Project.

Moreover, the Project has been collaborating with other JICA projects during the project implementation as follows.

- The Transport and Human Mobility Group improved the technology and enhanced the monitoring activities of the number of vehicles by types through the closed-circuit television (CCTV) in Yangon. The data was shared with the consultant team of Project for Improving Public Bus Service in Yangon (JICA's technical cooperation). Also, the Traffic Control Center of YRGA showed an intention to introduce this technology, the Project for Improving Public Bus Services is considering incorporating this activity in the project component.
- The research outcome of the relation between water-related disaster and poverty in Bago was shared with JICA experts of Urban Planning Project at YCDC.
- JICA has a plan to implement a new technical cooperation project for capacity enhancement of maintenance of bridges in Myanmar. Under the project, MOC, which the Project has worked together for bridge monitoring, will be the key counterpart and YTU will join in the project to provide technical support for high-level analysis of observational data.
- A simple monitoring system of bridge conditions, which the Project developed and utilized to Twantay and Pathein Bridges, will be applied to the construction of new Bago Bridge with support from JICA and the system is already included in the design of a new bridge.

1-5 Sustainability

The project sustainability examines whether the effects generated by the Project will continue after the cooperation term ends. Overall, sustainability is assessed as moderate as explained below.

Policy and institutional perspectives [High]

The policy environment in relation to disaster risk reduction has been favorable to date as stated in “1-1 Relevance”. The Government of Myanmar strongly committed to strengthening the disaster risk reduction as addressed in Myanmar Sustainable Development Plan 2018 – 2030 and Myanmar Action Plan on Disaster Risk Reduction 2017.

It seems that MOE will introduce a new policy to give universities a certain level of power of autonomy (semi-autonomy). Autonomy covers curriculum development, personnel, financial, and administrative issues. At this moment, it is not officially announced to what extent university will obtain the power of autonomy. When, even gradually, it is realized, this policy will assist YTU in keeping the teachers who enhanced their capacity through the Project staying at YTU and ensuring project sustainability.

Organizational perspective [Moderate]

In regard to the organizational aspect, the concerned issue is the teachers' relocation among universities which is yearly conducted based on the policy of MOE. The key teachers of YTU who have enhanced the research capacities through the project activities need to keep staying at YTU to ensure the organizational sustainability; however, they have to follow the MOE's decision for personnel relocation. Also, as other universities in Myanmar face, the number of teachers at YTU is not sufficient² and YTU needs a greater number of teachers and researchers to promote research activities. Since this also depends on the government decision, it is expected that a more number of teachers and researchers will be increased in the future.

Financial perspective [Moderate]

It is uncertain whether YTU can secure the budget for research since in Myanmar, not a large budget is allocated for the universities. YTU can allocate approximately 25 thousand USD annually for researches³. The Project has worked on the establishment of a Consortium, through which it is expected to acquire research fund for YTU; however, its full establishment is still on the way since the official approval of MOE for consortium's establishment is required to obtain research fund at the Consortium. The ICUS of The University of Tokyo has a plan

² According to the interview with YTU, the approved number of staff at YTU is 953; however, the total number of personnel is 620 now. Among 620, the teachers are 320. Also, there is a rumor that MOE may introduce autonomy of university in the late of 2020, allowing the universities to have authority over personnel issues. If this is realized, YTU may secure a more number of teachers in the future.

³ According to the interview with YTU.

to set up a base of research at YTU promoting collaborative researches in Myanmar and the plan and budget were approved in September 2019. At this moment, The University of Tokyo and YTU are examining how to make a remittance of research funds to YTU. Once the mode of remittance is identified, this research fund will greatly support for YTU's research activities. Another concern is the budget for repair of provided equipment. Since the budget for maintenance of equipment is limited at YTU and the Strategic Partners, this issue also affects the financial sustainability.

Technical perspective [Moderate]

The knowledge and technology transferred by the Project have been well accepted by the Myanmar counterparts and the project's Strategic Partners. The YTU's teachers have substantially enhanced the capacity of pursuing the research activities and the Strategic Partners have also learned how to utilize the systems developed by the Project. Since several key personnel of YTU has been trained for the research fields related to the Project, it is expected that the knowledge and skills enhanced by the Project will be transferred to other teachers and students, yet, the capacity of YTU needs to be enhanced continuously and advance for world-class research activities further. In this term, still YTU needs external support for continued capacity enhancement of research activities. At this moment, ICUS of the University of Tokyo is considering continued collaborative research with YTU under the umbrella of international cooperation scheme of ICUS. If this is realized, YTU will have a good opportunity to enhance their research capacity in the future.

There is a concern about the maintenance of equipment. As described "1-3 Efficiency", the English manuals for some of the provided equipment need to be prepared to ensure the technical sustainability. Besides, the repair of equipment is a challenging issue. During the project implementation, the broken microtremor and a hydro/meteorological sensor were repaired in Japan. Without the support of the Project after the project term ends, YTU and the Strategic Partners have to send the equipment necessary for repair work to abroad such as Singapore or Thailand since an agent or a branch office of equipment is not located in Myanmar. Notably, it is very difficult to identify a source of trouble of hydro/meteorological observational equipment since it requires the knowledge and experience of maintenance work, including IT and electronics. Currently, the Project is compiling the detailed information about equipment to ensure the technical sustainability. It is also expected that the continued support from ICUS of The University of Tokyo will be extended to YTU in the future. In sum, technical sustainability is assessed as moderate.

2. Key Factors Affecting Implementation and Outcomes

Social and political environments surrounding the Project have been relatively stable. However due to the status of YTU which has not yet acquired its autonomy, establishment of the Consortium was directly affected as YTU had to ask the Ministry of Education before making any decisions related to it and the Project had to adjust its plan and contents according to the request from the Ministry of Education several times. And every time, Myanmar's procedure responding to the Japan's answer took an incredible amount of time, resulting in a major hindrance to the action plan.

3. Evaluation on the results of the Project Risk Management

The Japanese side responded to the reformation of the ministerial structure without major issues and Myanmar side has also taken all necessary procedures such as visa and travel permission for the JICA experts.

IV. For the Achievement of Overall Goals after the Project Completion

1. Prospects to achieve Overall Goal

Overall Goal	Objectively Verifiable Indicators
YTU further utilizes the Collaboration Platform to contribute to the urban safety in Yangon and Bago	<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 YTU

Overall Goal is prospected to be achieved based on the following.

Objectively Verifiable Indicators for the Overall Goal have been achieved as mentioned in 2-2 Project Purpose and indicators, since a total of 5 policy related documents were already submitted during the Project and a total of 216 certified specialized persons were trained by YTU, UTokyo and other related organizations.

Moreover, new research projects have been formed as a result of the Project and its continuous effort by some groups such as Infrastructure group. A new project for technical transfer funded by JICA for road and bridge maintenance is formulated based on the output from the Project and the project leader of Infrastructure Group prepared a detailed plan in collaboration with MOC, YTU and Japanese organizations. In the next project, the equipment donated for the Project will continue to be utilized. Also research activity 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.

2. Plan of Operation and Implementation Structure of the Myanmar side to achieve Overall Goal

The Myanmar side shall continue its communication with MOE to realize the establishment of the Consortium which is at the final stage of getting approval as of March 2020. YTU is expected to continue research activities as it has been doing for the past years during the Project period and promote a full utilization of resources provided by the Project such as facility of the Research Center, donated equipment and collaborative relationship with the Strategic Partners which are key organizations to contribute to the urban safety in Yangon and Bago.

3. Recommendations for the Myanmar side

(1) Strengthen the organizational capacity of RS/GIS RC

It is recommended that YTU strengthens the capacity of RS/GIS RC by making decisions regarding human resource and financial matters. For example, selecting the members of a management committee, allocating the staff, securing research funds, services and outputs which RS/GIS RC can offer, and collaboration protocol to promote research activities with the Strategic Partners and other institutes. These issues need to be examined considering the policy of the university's semi-autonomy to be introduced in coming October 2020.

Actions taken in response to Recommendation (1):

The Japanese side requested the Myanmar side to consider the following three possibilities to strengthen the organization; 1) inviting visiting professors, 2) accepting public application for human resource, 3) promoting human resource within YTU including other fields such as Forestry or Geography. The Project members, especially Prof. Sao Hone Pha and Prof. Kyaw Zaya Htun, the Directors of RS/GIS RC and the Japanese counterpart Professor Dr. Takeuchi from RS/GIS RC put a great effort in establishing a strong network between YTU and MTU while supporting to strengthen MTU's RS/GIS section for future collaboration between the two universities.

On 13 February 2020, a joint workshop between RS/GIS groups from MTU, YTU and UTokyo was held successfully and three action items were proposed to continue collaborative research activities; 1) Extraction of building footprint for all townships in

Yangon: YTU agreed to request YCDC to validate extracted shape files and plans to participate in One-Map Project for YCDC which will help increase YTU's accessibility to information; 2) Flood monitoring in Yangon and Mandalay region during rainy season: MTU plans to conduct flood mapping for Mandalay using ground flood marks points by surveying with RTK after one week of flood period. YTU and MTU can use these ground check points to validate flood maps from both Sentinel images and PALSAR 2 images; 3) Extraction of building footprint for Mandalay: Permission from MCDC is needed to gain access to Mandalay's UAV image data to be used for a training and also permission from JICA is needed to use building footprint data of Mandalay.

(2) Establishment, management and operation of the Consortium

It is expected that the YTU to complete the establishment of the Consortium which is already under finalization process. Under the Consortium, research activity and collaboration among the members of the Consortium shall be promoted and YTU to take a leading role to encourage active participation among government, academia and industry to contribute to the urban safety in Yangon and Bago.

Actions taken in response to Recommendation (2):

The Project put a great effort in order to get a permission from MOE for establishing the Consortium before the end of the Project by continuing to communicate by all means including direct contact, emails and phone calls for the realization. Thanks to a committed work by SATREPS Project Office at YTU, YTU completed the Article of Association (See Annex 2-5_18) and prepared a final set of documents including the names of signing persons requested by MOE and submitted in March 25. The Project planned to have a formal signing event for the establishment of the Consortium during a final ceremony for the Project which was scheduled to be held in Yangon at the end of March, however a ceremony was postponed due to covid-19 situation and the Project ended before receiving official permission from MOE for the establishment of the Consortium. As of 31 of March, the documents have been reviewed by MOE and YTU continues to wait for a response from MOE.

(3) Management of donated equipment

It is recommended that YTU promotes active and effective use of donated equipment for research activities while ensuring a sustainable maintenance system for a long-term use of the equipment. Using an "Equipment List" made by the Project and provided to YTU including all the necessary information about each equipment such as name, purpose, availability of manuals, and contact information of the manufacturer, etc., proper

management of all the donated equipment shall be carried out. For some equipment, it may be difficult to repair as no technical support may be available in Myanmar and therefore, it is expected that YTU and the Strategic Partners will make maximum efforts to keep the lifetime of equipment longer with proper maintenance work.

Actions taken in response to Recommendation (3):

A list of Equipment was compiled by a committed work by SATREPS Project Office at YTU (See Annex 1-4 List of Donor Equipment updated 20200318). The list includes important information which is necessary for maintenance such as manual availability, company & contact info and warranty as well as the names of responsible person for the equipment in YTU. Manuals for the equipment both made by the Project and provided by the manufacturers were attached in the Annex 1-5.

(4) Utilization of the Systems developed by the Project

YTU shall become familiar with 3 systems developed by the Project and actively promote their usage to the counterparts at YTU as well as Strategic Partners. Practical training course and seminars can be conducted regularly to potential users.

Actions taken in response to Recommendation (4):

Workshops and seminars were conducted by the Project in order for the Myanmar side to be familiarized with the system.

Disaster Management Group under Prof. Tun Naing and Dr. Numada conducted workshops and seminars at YTU together with concerned Strategic Partners including GAD, DDM, and YCDC, demonstrating the Disaster Management Support System. The flow chart of Disaster Management Support System was translated into Myanmar language in order to make it accessible to Myanmar users. See website: <http://eng.iis-boss.com/work-flowchart#> (ID: myanmar_admin, PW: kumamon).

Transportation Group organized a training to YTU students in December 2019 to demonstrate "City Geospatial Dashboard" and collected building information with smartphones together with RS/GIS Group. The group also conducted a workshop in January 2020 to demonstrate cloud-based CCTV vehicle counting, interactive spatial analysis and geo-visualization functions for hourly Grid-population, Link-speed, and People flow and direction, resulting from students' research outcomes. Participants including YCDC, Myanmar Transport Authority, Yangon Bus Service, Crime and Traffic Accidents Control Center, Myanmar Management Information Unit and ALMEC had

active discussion about future mitigation of traffic congestion and accidents, use of big data especially CDR for Yangon City development project and future research & development collaboration with YTU and UTokyo. See websites for two systems: <https://myanmar.geospatial.jp/ckan> for Myanmar G-Spatial Information Dashboard and https://harmony-geospatial-analytics.com/city_geospatial_dashboard for City Geospatial Dashboard.

Water-related Disaster Group under Profs. Win Win Zin and Kawasaki, Dr. Seemanta Bhagabati conducted a workshop and a seminar at YTU together with Strategic Partners including IWUMD, DWIR, DMH, DDM and DHPI, demonstrating the Near-realtime Inundation Analysis System for Bago River basin. Also, workshops were held in Bago with local Strategic Partners including Bago Region Chief Minister, and the system was directly introduced to Director Generals and high-level officers of DMH and DHPI in Nay Pyi Taw and to Acting Director General of DWIR in Yangon. The System is accessible among Strategic Partners via internet, and graphical user interfaces for both desktop PC and smart phone are developed.

(5) Continuation of research activities

It is recommended that YTU continues research activities and promotes them further at YTU applying knowledge and skills enhanced through the Project activities. It is expected that YTU teachers and students submit the academic papers for international journals and present the research results at the conference of the Myanmar Society of Civil Engineers established in 2019. Moreover, it is recommended that YTU conducts these research activities based on the needs of the Consortium members. This will contribute to accumulate more results and achievements as the Consortium's activities, which demonstrates its significance and creates a virtuous cycle of fundraising for research activities.

Actions taken in response to Recommendation (5):

The Project members supported research activities of YTU by encouraging to submit papers to journals and conferences. As a result, in the remaining half year of the Project (from October 2019 to March 2020), 31 research papers were submitted to peer review international journals (18 papers written with Myanmar side as main author) and 32 research papers were presented at conferences (12 by Myanmar side as main author) (See Annex 5-9_Monitoring Sheet No,9).

4. Monitoring Plan from the end of the Project to Ex-post Evaluation

Ex-post Evaluation of the Project shall be conducted after three years of project completion as one of the requirements of the Japanese Official Development Assistance (ODA) scheme.

- (1) The status of the Consortium and its activities shall be monitored in order to check the effect of governmental, academia and industry collaboration and its contribution to the urban safety in Yangon and Bago (e.g., meeting minutes, activity records, etc.).
- (2) The role and activity of the RS/GIS Research Center shall be monitored to check how it has contributed to create an active research environment and also its involvement with the Consortium as a facilitating organization (e.g., activity records, seminars, research projects, consortium support activity records, etc.).
- (3) The condition of the donated equipment shall be monitored thoroughly using the “equipment list” to check how often, which kind of equipment are utilized, for what purposes. Also its maintenance management shall be monitored to make sure it is used properly (e.g., records of usage of equipment, purpose, period, place, name of user, condition (with or without breakdown or damage) at the time of return, etc.).
- (4) Three systems developed by the Project shall be monitored to check how they have been used to contribute to the urban safety of Yangon and Bago and how they have been updated and / or maintained properly to be used properly (e.g., records of usage or introduction by ministries and companies, and update / modification).
- (5) Research activities of YTU faculty members and students shall be monitored to check if the research activities have continued after the completion of the Project by checking the number of papers submitted to international journals and the number of presentations at international and domestic conferences and the number of presentations at international and domestic conferences.

END

ANNEX 1: Results of the Project

- 1-1 List of Dispatched Experts
- 1-2 List of Counterparts
- 1-3 List of Training
- 1-4 List of Equipment provided by the Project (See Separate Volume)
- 1-5 List of Manuals for Donated Equipment (See Separate Volume)
- 1-6 Cost of Operation

ANNEX 2: List of Products Produced by the Project

- 2-1 List of Research Papers
- 2-2 List of Policy Related Documents (See Separate Volume)
- 2-3 List of Systems (See Separate Volume)
- 2-4 List of Persons acquired degrees
- 2-5 List of Other Products (See Separate Volume)

ANNEX 3: PDM (All versions of PDM)

- 3-1 PDM Version 0 Approved in April 2015
- 3-2 PDM Version 1 Approved in Nov. 2017

ANNEX 4: R/D, M/M, Minutes of JCC (See Separate Folder for below documents)

- 4-1 Minutes of Meeting 19 September 2014
- 4-2 Record of Discussion 9 April 2015
- Minutes of Meeting (Amended RD) 10 May 2018
- 4-3 Minutes of Meeting from JCC No.1 15 September 2015
- 4-4 Minutes of Meeting from JCC No.2 13 September 2016
- 4-5 Minutes of Meeting from JCC No.3 26 October 2017
- 4-6 Minutes of Meeting from JCC No.4 30 October 2018
- 4-7 Minutes of Meeting from JCC No.5 1 October 2019

ANNEX 5: Monitoring Sheet (See Separate Folder for below documents)

- 5-1 Monitoring Sheet No.1 2016.4
- 5-2 Monitoring Sheet No.2 2016.10
- 5-3 Monitoring Sheet No.3 2017.7
- 5-4 Monitoring Sheet No.4 2017.10
- 5-5 Monitoring Sheet No.5 2018.5
- 5-6 Monitoring Sheet No.6 2018.10
- 5-7 Monitoring Sheet No.7 2019.9
- 5-8 Monitoring Sheet No.8 2020.3
- 5-9 Monitoring Sheet No.9 2020.3

Separate Volume: Copy of Products Produced by the Project

- Annex 1-4 List of Equipment photos
- Annex 1-5 List of Manuals for Donated Equipment
- Annex 2-2 Policy Reports
- Annex 2-3 List of Systems
- Annex 2-5 List of Other Products