Mozambique
INAM

TECHNICAL COOPERATION PROJECT FOR THE CAPACITY ENHANCEMENT OF METEOROLOGICAL OBSERVATION, WEATHER FORECASTING AND WARNING IN MOZAMBIQUE

FINAL REPORT

September 2018

Japan International Cooperation Agency

Japan Meteorological Business Support Center

The Project Site

UN Caritography Section, July 2014.

Photos of the project (1)

Baseline survey(Maputo)

Baseline survey(Beira)

Baseline survey (XaiXai)

National Director Meeting

Inspection
for South Africa Weather Service

Inspection for INNOQ

Photos of the project (2)

Calibration room of INAM

Discussion for traceability

Lecture (Equipment maintenance)

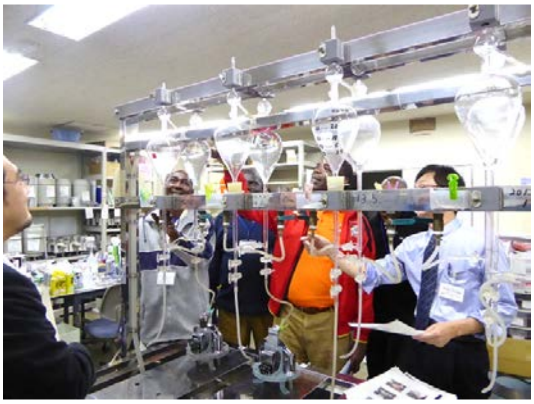
Lecture (GPV usage)

Survey for electric power (Beira)

Confirmation of spare parts (Beira)

Photos of the project (3)

RADAR product inspection (INAM-HQ)



Rain gauge inspection (RIC Tsukuba)

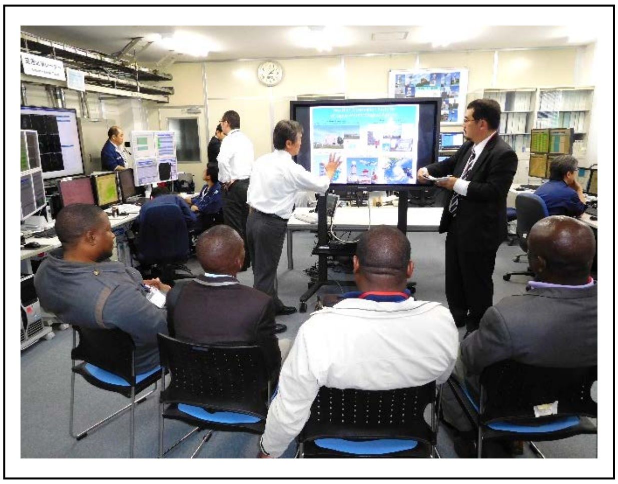
Barometer calibration (RIC Tsukuba）

Discussion for warning evaluation (INAM)

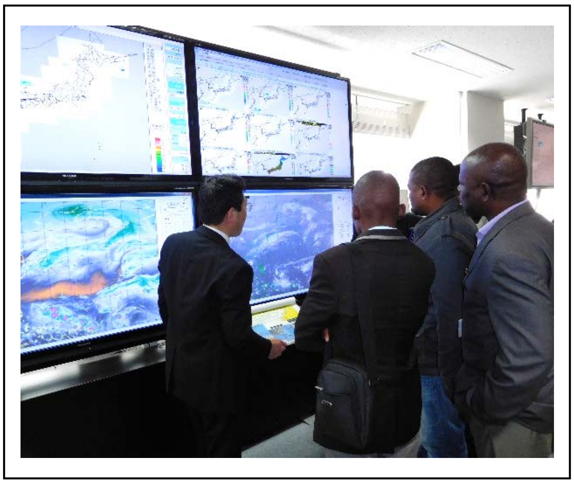
Interview for users (Noticias)

TV system of INAM

Photos of the project (4)



Technical visit to JMA observation room (JMA)



Technical visit to JMA forecasting room (JMA)

Technical visit to Sapporo RHQ (JMA)

Exercise on temperature guidance (JMBSC)

ARG installation (Numpula)

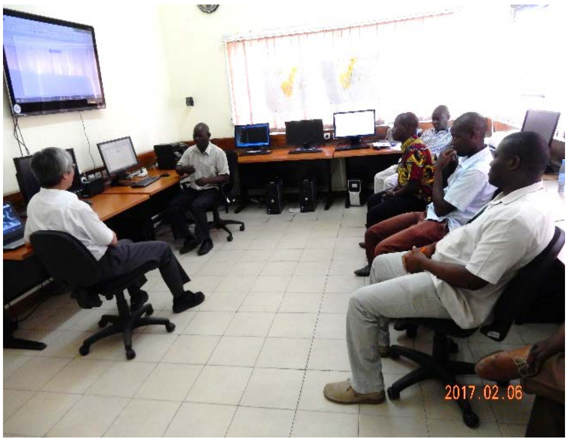
Photos of the project (5)

On-site training (Beira: traceability)

On-site training (Inhambane: observation)

Calibration of electric thermometer

OJT on the utilization of GPV



Forecast briefing with large screen

Explanation of Cyclone DINEO to media

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Glossary

Abbreviation	Meaning
ARG	Automatic Rain Gauge
AWS	Automatic Weather Station
CAPPI	Constant Altitude Plan Position Indicator (radar)
C/P	Counterpart Personnel
DNA	National Directorate of Water
DRR	Disaster Risk Reduction
EFCOS	Effective Flood Control Operation System
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GPV	Grid Point Value
GSM	Global Spectrum Model
INAM	National Institute of Meteorology
INNOQ	Instituto Nacional de Normalizacao e Qualidate
INGC	National Institute of Disaster Management
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
JMA	Japan Meteorological Agency
MIC	Meteorological Instrument Center
M/M	Meeting minutes
MOS	Model Output Statistics
NWP	Numerical Weather Prediction
PDM	Project Design Matrix
PO	Plan of Operation
PPI	Plan Position Indicator (radar)
QPE	Quantitative Precipitation Estimation
R/D	Record of Discussion
RIC	Regional Instrument Center
RSMC	Regional Specialized Meteorological Center
SADIS	Satellite Distribution System (Aviation)
SATAID	Satellite Animation and Interactive Diagnosis
SMS	Short Messaging Service
SWFDP	Severe Weather Forecast Demonstration Project
SYNOP	Surface Synoptic Observation
TDM	Telecomunicações de Moçambique
UPS	Uninterruptible Power Supply
W/P	Work Plan
WMO	World Meteorological Organization

Chapter 1. Project Purpose

1.1 Background

Economic development and poverty reduction in Mozambique are influenced by climatic variability, extreme climatic events and climate change. The nation is particularly vulnerable to natural disasters such as floods, tropical cyclones and droughts, whose frequency has increased in the last decade. Mozambique is particularly known among African nations for the severity and frequency of its influence from tropical cyclones. Against such a background, the achievement and maintenance of national economic development are dependent on efforts to mitigate the negative effects of weather-related natural disasters.

To support economic development in Mozambique and contribute to national safety and public wellbeing, the nation must enhance its capacity for response to weather-related natural disasters. In particular, its National Institute of Meteorology (INAM) must strengthen its capabilities in relation to meteorological observation, forecasting and warnings.

1.2 Project purpose and output

This project is intended to help enhance Mozambique’s capacity for response to natural disasters via strengthened observation, forecast and warning capacity on the part of INAM based on calibrated and traced observation data.

(1) Overall goal

Capacities to respond the natural disasters are enhanced in Mozambique.

(2) Project Purpose

INAM is capable to issue improved weather forecasting and warnings by using quality-controlled meteorological data.

(3) Project Purpose and verifiable indicators

OUTPUT 1: Capacities in meteorological observation at INAM are enhanced

1-1: Developed guidelines and manuals for the traceability and inspection of meteorological instruments

1-2: Developed guidelines for the monitoring heavy rain with satellite data and ARG (Automated Rain Gauge) data.

1-3: Training on meteorological instrument calibration is conducted for at least 3 INAM staffs in charge for calibration.

1-4: Meteorological instruments ensured traceability of calibration are at least XX%

OUTPUT 2: Capacities in weather forecasting and warnings at INAM are enhanced

2-1: At least 3 staff of INAM obtains ability to use ground observation, ARG, satellite and GPV data for forecasting.

2-2: At least 3 staff, in charge for operational forecast, of INAM obtains ability to operate comprehensive weather forecasting.

(4) Activities of each OUTPUT

OUTPUT 1: Capacities in meteorological observation at INAM are enhanced

1-1. Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others.

1-2. Procured traveling standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible for second calibration.

1-3. Develop guidelines for the monitoring heavy rain with satellite and ARG data and checkup list for ARG.

1-4. Develop guidelines and manuals for the traceability and inspection of meteorological instruments

1-5. Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data.

1-6. Conducting training for the traceability and inspection of meteorological instruments according to guidelines and manuals based on the activity 1-4

1-7. Conduct follow-up activities to monitor and analyze heavy rain on daily operation.

1-8. Conduct follow-up activities to establish the traceability and inspection of meteorological instruments

OUTPUT 2: Capacities in weather forecasting and warnings at INAM are enhanced

2-1. Conduct baseline survey and identify issues about forecasting and warning

2-2. Conduct training of weather forecasting method.

2-3. Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, ARG, satellite and GPV data.

2-4. Conduct follow-up activities to establish comprehensive weather forecast and warning by using the output of activity 2-2 and 2-3.

2-5. Conduct baseline survey to identify needs of users such as INGC, DNA, Media and private company and identify issues on weather forecast and warning product provided by INAM.

2-6. Improve weather forecast and warning base on the finding of activity 2-5.

As outlined in Chapter 2.5, one of the targets of transfer of technical expertise was changed at the second JCC meeting held on the 22nd of September 2015 from ‘Enhance forecasting and warning ability with radar data’ to ‘Enhance forecasting and warning ability with satellite and AWS data.’ In line with this modification, related activities were revised as follows:

1-3. Develop guidelines for the monitoring heavy rain with satellite and ARG data and conduct training.

1-5. Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data.

1-7. Conduct follow-up activities to monitor and analyze heavy rain on daily operation.

2-3. Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, ARG, satellite and GPV data.

Chapter 2.　Project Activities

2. 1　Project implementation structure

The project is based on the policies and concepts shown in Table 2-1 and Fig. 2-1.

Table 2-1 Basic project policies

Policy 1:　Foster the development of observation/forecast experts in line with INAM’s strategic plan (transfer/sharing of JMA technical expertise and experience)
Policy 2:　Establish traceability (reliability) in observation
Policy 3:　Foster the development of observation experts and prepare for switchover to AWS
Policy 4:　Foster the development of forecast experts and document forecasting expertise
Policy 5:　Promote the production of user-friendly weather information

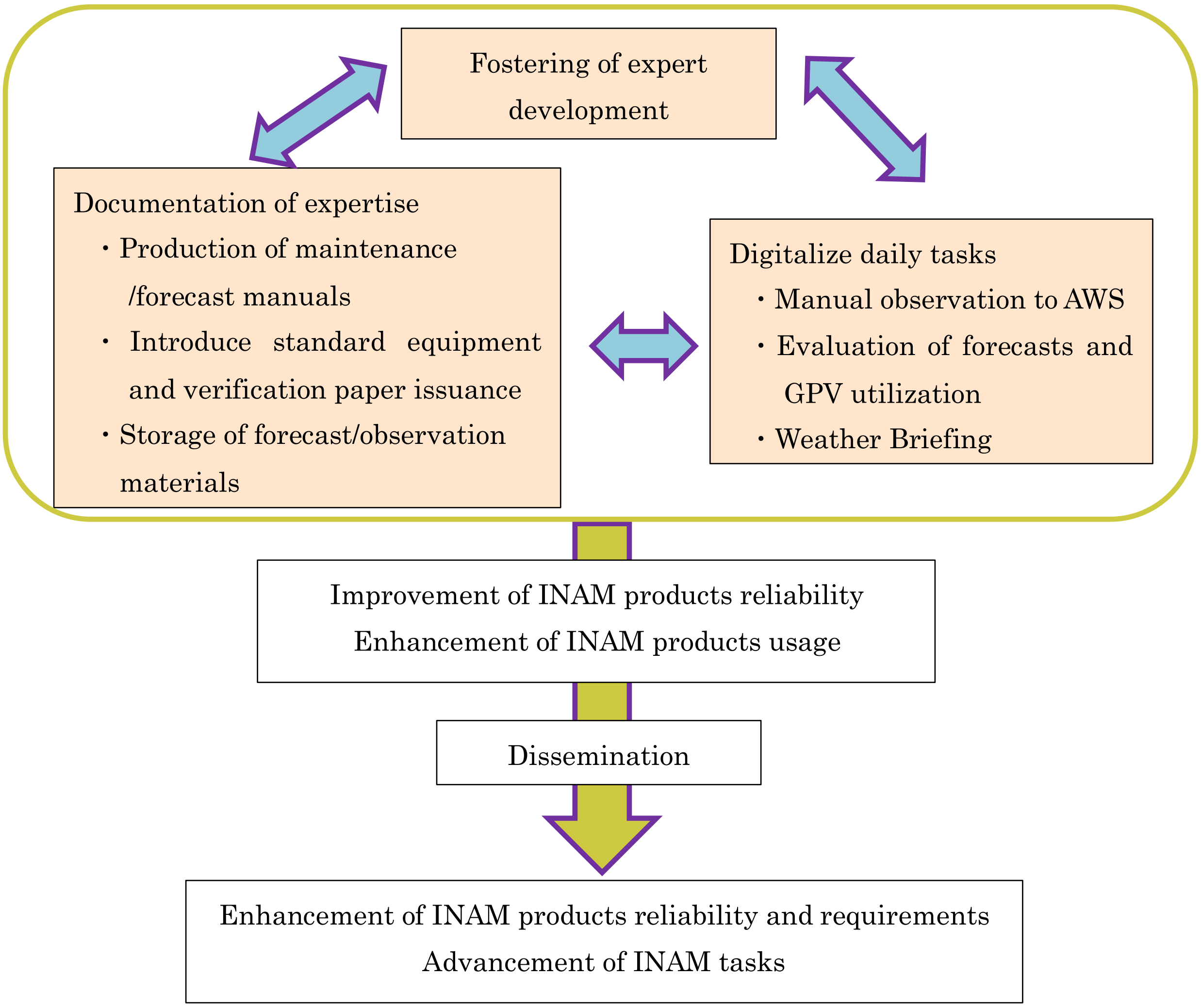


Fig. 2-1　Project concepts

The initial project structure of the expert team (referred to here simply as ‘the team’) is shown in Fig. 2-2. However, the radar reviews at scheduled for Xai-Xai and Beira under the World Bank project were incomplete at this point, and the team was unable to implement transfer of technical expertise for radar operation, maintenance and usage. To address related problems and support the compilation of a recommendation report for improvement of the situation, two radar experts (one specializing in hardware and the other in software) dispatched in October 2015 reported a proposal for the review of both radars to INAM and JICA.

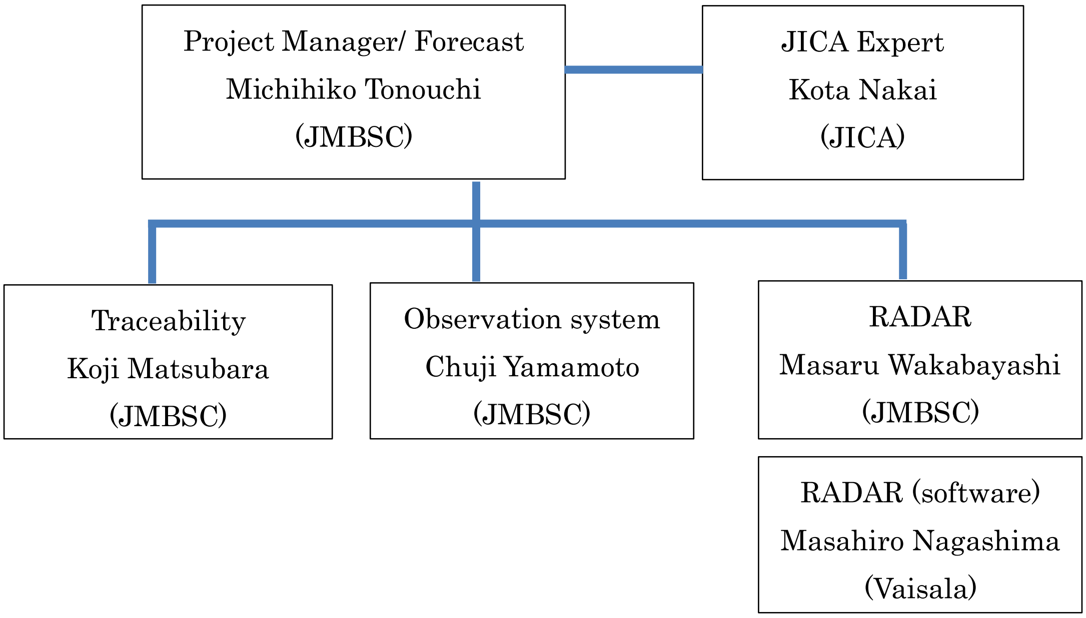


Fig. 2-2 Expert team structure (as of March 2016)

In March 2016, there was no stable supply of electricity to the radars in Xai-Xai and Beira and no possibility of radar review during this project period. As a result, one of the project activity targets was changed from ‘Transfer of technical expertise for forecasting/warning with radar data’ to ‘Transfer of technical expertise for forecasting/warning with satellite and AWS data’ at the JCC meeting held on the 22nd of September 2016. In conjunction with this modification, the expert team structure was modified as shown in Fig. 2-3.

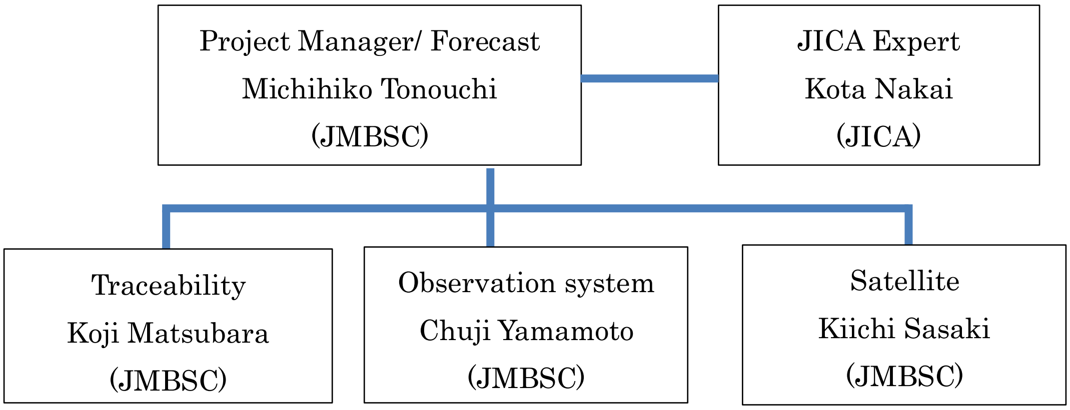


Fig. 2-3 Expert team structure (as of September 2016)

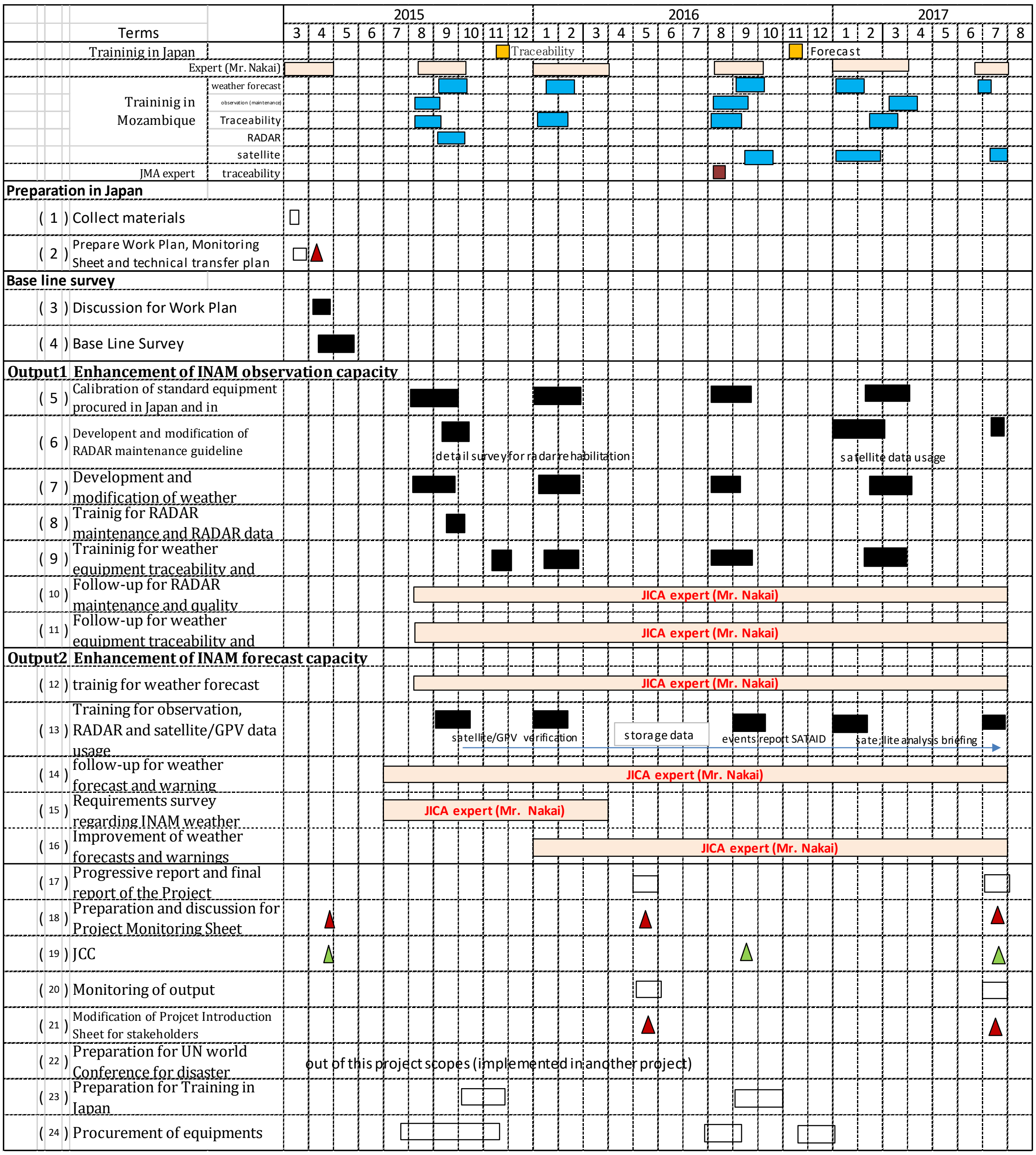
C/P teams established by INAM for the activities are following Divisions; Observation and IT/network

Division for observation and traceability, Forecast and Climate Division for forecast and satellite.

2. 2 Project implementation results

The results of project implementation are shown in Table 2-2. As detailed in the previous section, the focus of one of the project targets was changed from radar to satellite. To strengthen traceability and observation protocols, one of the activities scheduled to be implemented by the observation expert was transferred to the traceability expert.

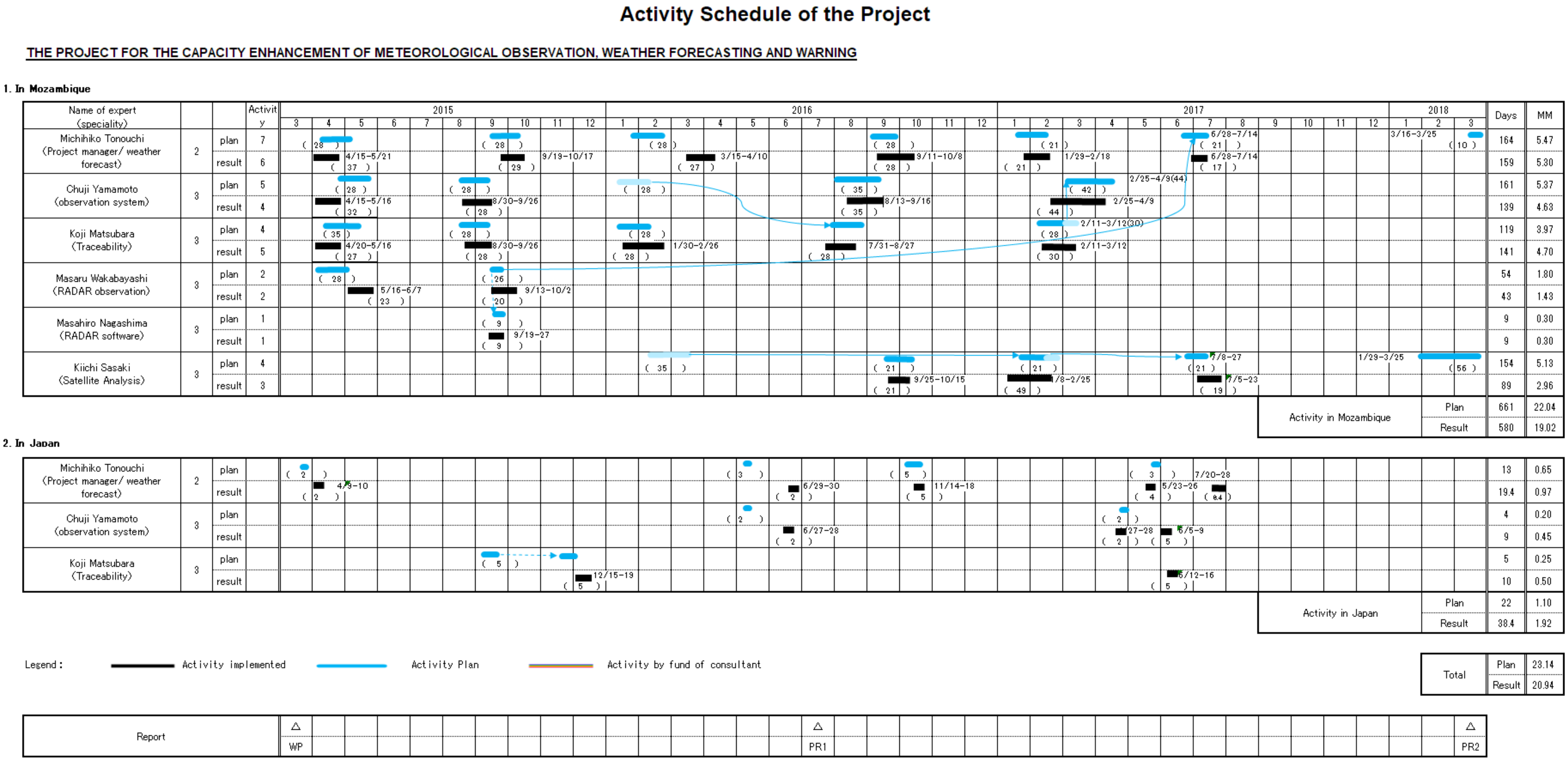
Table 2-2. Project implementation results



2. 3 Expert activities

Expert activities are shown in Table 2-3.

Table 2-3. Experts activities



Activity Schedule of the Project

THE PROJECT FOR THE CAPACITY ENHANCEMENT OF METEOROLOGICAL OBSERVATION, WEATHER FORECASTING AND WARNING

1. In Mozambique

Name of expert (speciality)			Activity	2015 – 2018	Days	MM
Michihiko Tonouchi (Project manager/ weather forecast)	2	plan	7	(28) (28) (28) (28) (21) 6/28-7/14 (21) 3/16-3/25 (10)	164	5.47
		result	6	4/15-5/21 (37) 9/19-10/17 (29) 3/15-4/10 (27) 9/11-10/8 (28) 1/29-2/18 (21) 6/28-7/14 (17)	159	5.30
Chuji Yamamoto (observation system)	3	plan	5	(28) (28) (28) (35) 2/25-4/9(44) (42)	161	5.37
		result	4	4/15-5/16 (32) 8/30-9/26 (28) 8/13-9/16 (35) 2/25-4/9 (44)	139	4.63
Koji Matsubara (Traceability)	3	plan	4	(35) (28) (28) 2/11-3/12(30) (28)	119	3.97
		result	5	4/20-5/16 (27) 8/30-9/26 (28) 1/30-2/26 (28) 7/31-8/27 (28) 2/11-3/12 (30)	141	4.70
Masaru Wakabayashi (RADAR observation)	3	plan	2	(28) (26)	54	1.80
		result	2	5/16-6/7 (23) 9/13-10/2 (20)	43	1.43
Masahiro Nagashima (RADAR software)	3	plan	1	(9)	9	0.30
		result	1	9/19-27 (9)	9	0.30
Kiichi Sasaki (Satellite Analysis)	3	plan	4	(35) (21) (21) 7/8-27 (21) 1/29-3/25 (56)	154	5.13
		result	3	9/25-10/15 (21) 1/8-2/25 (49) 7/5-23 (19)	89	2.96

		Days	MM
Activity in Mozambique	Plan	661	22.04
	Result	580	19.02

2. In Japan

			2015 – 2018	Days	MM
Michihiko Tonouchi (Project manager/ weather forecast)	2	plan	(2) (3) (5) (3) 7/20-28	13	0.65
		result	4/9-10 (2) 6/29-30 (2) 11/14-18 (5) 5/23-26 (4) (8.4)	19.4	0.97
Chuji Yamamoto (observation system)	3	plan	(2) (2)	4	0.20
		result	6/27-28 (2) 27-28 (2) 6/5-9 (5)	9	0.45
Koji Matsubara (Traceability)	3	plan	(5)	5	0.25
		result	12/15-19 (5) 6/12-16 (5)	10	0.50

		Days	MM
Activity in Japan	Plan	22	1.10
	Result	38.4	1.92

Legend : Activity implemented Activity Plan Activity by fund of consultant

Total	Plan	23.14
	Result	20.94

Report: △ WP (2015-3) △ PR1 (2016-7) △ PR2 (2018-2)

2. 4 PDM modification

The radars in Xai-Xai and Beira were supposed to be repaired under the World Bank project, but neither had been maintained by the beginning of the project and operation could not be resumed. The team implemented a detailed survey for the review of both radars from September to October 2015, and a summary review plan/recommendation report was submitted to INAM and JICA. It was agreed that since the radars would not be repaired by the end of the project, the focus of the target of technical expertise should be modified from radar to satellite and AWS. At the 2nd JCC held on the 22nd of September 2016, INAM and JICA agreed on the PDM modification shown in Table 2-5 with the intermediate project evaluation shown in Table 2-4.

Due to the mid-project target change from transfer of technical expertise for forecasting with radar data to transfer of technical expertise for forecasting with satellite and AWS data, the effectiveness of satellite expert activities was limited in a situation covering only one rainy season. To incorporate a variety of heavy-rain events, the team proposed the extension of the project period for transfer of technical expertise for forecasting with satellite and AWS data at the 3rd JCC held on the 7th of July 2017, and INAM/JICA agreed.

Table 2-4.　Project intermediate evaluation (2nd JCC)

Status of the Project Activities		means of verification	Actual status	Catch-up plan
1-1	Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others.		finished	
1-2	Procured travel standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible from second calibration.		finished	
1-3	Develop guidelines for the quality control of meteorological radar data and check-up list for meteorological radar.	will be changed		
	Develop guidelines for monitoring heavy rain with satellite and ARG data and checkup list for ARG		ARG setting is prepared, lectures for satellite usage is prepared in Sep. to Oct. 2016	OJT for watching and forecasting for heavy rain is scheduled in Jan. to Mar. 2017
1-4	Develop guidelines and manuals for the traceability and inspection of meteorological instruments.		1st. Draft was reported	will be improved based on trainings in local observatories
1-5	Conduct trainings for the quality control of meteorological radar data and checkup for meteorological radar according to guidelines and checkup list based on the activity 1-3.	will be changed		
	Conduct trainings for monitoring and analysis for heavy rain with satellite and ARG data		Lectures for satellite usage is prepared in Sep. to Oct. 2016	OJT for watching and forecasting for heavy rain is scheduled in Jan. to Mar. 2017
1-6	Conduct trainings for the traceability and inspection of meteorological instruments according to guidelines and manuals based on activity 1-4.		implemented	review at INAM-HQ and comparisonin in local observatories in Feb. 2017
1-7	Conduct follow-up activities to establish the quality control of meteorological radar data and checkup for meteorological radar.	will be changed		
	Conduct follow-up activities to monitor and analyze heavy rain on daily operations.		Lectures for satellite usage is prepared in Sep. to Oct. 2016	OJT for watching and forecasting for heavy rain is scheduled in Jan. to Mar. 2017
1-8	Conduct follow-up activities to establish the traceability and inspection of meteorological instruments.		being implemented (HQ and XaiXai)	will be implemented in local observatories in Feb. To Apr. 2017
2-1	Conduct baseline survey and identify issues about weather forecasting and warning.		finished	
2-2	Conduct trainings of Weather forecasting Method.		implemented and on going (how to use GPV, satellite data usage)	trial for weather guidance is prepared
2-3	Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, meteorological radar, satellite and GPV data.		weekly calibration and monthly report have been reported	OJT with satellite, GPV and observation data in Jan. to Mar. 2017
	Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, ARG, satellite and GPV data.	will be modified		
2-4	Conduct follow-up activities to establish comprehensive weather forecast and warning by using the output of activity 2-2 and 2-3.		being implemenmted	continuing
2-5	Conduct baseline survey to identify needs of each users such as INGC, DNA, Media and private company and identify issues on weather forecast and warning provided by INAM.		implemented by Mr. Nakai in Apr. 2016 and implemented through baseline.	
2-6	Improve weather forecast and warning based on the findings of activity 2-5.		need to be discussed	Should be discueesed which activities and output would be expected.

Status of Producing Expected Outcome (PDM OVI: indicators)

OUTPUT-1. Capacities in meteorological observation at INAM are enhanced.

1-1	Developed Guidelines and manuals for the traceability and inspection of meteorological instruments.		1st. Draft was reported as appendix of progressive report	will be improved through trainings
1-2	Developed guidelines for the quality control of meteorological radar data and chekup list for meteorological radar.		ARG setting is prepared.	Guideline for ARG data will be developped and lecture will be implemented in Jan 2017
	Developped guidelines for monitoring heavy rain with satellite data and ARG (automated Rain Gauge) data.	will be modified		
1-3	Training on meteorological observation is conducted for at least xx INAM staff.		implemented for maintenance section staffs through RIC and INAM-HQ trainings implemented for 39 trainees in Aug. and Sep. 2016 at INAM-HQ	Traininigs at lodal oibservatories will be scheduled in Feb. to Apr. 2017
	Training on meteorological observation is conducted for at least 3 INAM staffs in charge for operational observation/calibration..	will be modified		
1-4	Meteorological instruments which ensure traceability of calibration are at least xx%.		INAM national standard and traveling standards become traceable	Traceability to equipments in local observatories will be scheduled in Feb, to Mar. 2017

OUTPUT-2. Capacities in weather forecasting and warnings at INAM are enhanced.

2-1	At least xx staff of INAM obtains ability to use ground observation, radar, satellite and GPV data for forecasting.	guideline and Manual Assessment by JICA experts Project Reports Certification	Lectures for astellite, GPV, forecast verification are implemented. And warning evaluation is being implemented. At least 3 staffs (verification team) obtains ability to use GPV, satellite and observed data,	OJT for wtching and forecasting for heavy rain willl be scheduled in Jan. to Mar. 2017
	At least 3 staffs of INAM obtains ability to use ground observation, ARG, satellite and GPV data for forecasting.	will be modified		
2-2	At least xx staff of INAM obtains ability to operate comprehensive weather forecasting.	Assessment by JICA experts Project Reports	Trail for weather guidance is prepared	trial would be continued in Jan. and Jul. 2017
	At least 3 staffs, in charge for operational forecast, of INAM obtains ability to operate comprehensive weather forecasting.	will be modified		

Status of Achieving Desired Outcomes

Project purpose: INAM is capable to issue improved weather forecast and warnings by using quality-controls meteorological data.

(1)	Improved contents of weather forecasts and warnings.	Project reports Documents of weather forecast and warnings	INAM started warning for district levels from 2015 rainiy season.	Should be discueesed which activities and output would be expected.

Status of Attaining Intended Impact

Overall Goal: Capacities to respond the natural disasters are enhanced in Mozambique.

1)	More than xx% of local authorities and other relevant agencies in disaster risk reduction and management highly recognize that INAM services are timely and effective.	Interviews survey to Mozambican relevant agencies in disaster risk reduction and management. Satisfactory Survey.	need to be discussed	Should be discueesed which activities and output would be expected.

color	🟩	On going or prepared
legend	🟨	Implemented
	🟪	Should be discussed

Table 2-5. PDM modification (2nd JCC)

	Previous PDM	Modification of PDM
Objectively Verifiable Indicators		
Output 1-2.	Developed guidelines for the quality control of meteorological radar data and checkup list for meteorological radar.	Developed guidelines for the monitoring heavy rain with satellite data and ARG (Automated Rain Gauge) data.
1-3.	Training on meteorological observation is conducted for at least XX INAM staff.	Training on meteorological instrument calibration is conducted for at least 3 INAM staffs in charge for calibration.
2-1.	At least XX staff of INAM obtains ability to use ground observation, radar, satellite and GPV data for forecasting.	At least 3 staff of INAM obtains ability to use ground observation, ARG, satellite and GPV data for forecasting.
2-2.	At least XX staff of INAM obtains ability to operate comprehensive weather forecasting	At least 3 staff, in charge for operational forecast, of INAM obtains ability to operate comprehensive weather forecasting
Activities		
1-3.	Develop guidelines for the quality control of meteorological radar data and checkup list for meteorological radar	Develop guidelines for the monitoring heavy rain with satellite and ARG data and checkup list for ARG.
1-5.	Conduct trainings for the quality control of meteorological radar data and checkup for meteorological radar according to guidelines and checkup list based on the activity 1-3	Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data.
1-7.	Conduct follow-up activities to establish the quality control of meteorological radar data and checkup for meteorological radar.	Conduct follow-up activities to monitor and analyze heavy rain on daily operation.
2-3.	Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, meteorological radar, satellite and GPV data.	Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, ARG, satellite and GPV data.

2. 5 JCC and meetings with the Director General

2. 5. 1 JCC

Based on JICA's Detailed Survey Report on Enhancement of Observation/Forecasting/Warning Capacity in Mozambique, the World Bank's Project Appraisal Document and discussions in the context of INAM activities, the team reported on its Project Work Plan at the 1st JCC held on the 29th of April 2015. At the meeting, INAM and JICA agreed on the plan and agreed to transfer technical expertise before the commencement of the baseline survey. The plan and the meeting minutes are provided in Appendix D-1.

At the 2nd JCC held on the 22nd of September 2016, as INAM and the team were unable to use operational radar data, the team reported its intermediate evaluation for the project and proposed that the project target of transfer of technical expertise for forecasting/warning with radar data be modified to transfer of technical expertise for forecasting/warning with satellite and AWS data. INAM and JICA agreed on the change and the modification of the PDM. The meeting minutes are provided in Appendix D-2.

At the 3rd JCC held on the 7th of July 2017, the team submitted the latest project report, along with a final evaluation, training materials and related products, to INAM. The meeting minutes are provided in Appendix D-3.

In addition, the Project open seminar including project final report was held on the 19th of March 2018 and a wrap-up meeting with INAM staff was held on 22nd of March 2018.

1st JCC: 29th of April 2015
Venue: INAM meeting-room
Proceedings: Roles of Meteorological Services (Kota Nakai)
Project Work Plan (Michihiko Tonouchi)
Discussion
Attendees: INAM National Director, Vice-Director and others
JICA Mozambique Chief Representative, Senior Representative,
Project Formulation Advisor, Kota Nakai (expert) and others
JCC member DNA and others
Consultant team

2nd JCC: 22nd of September 2016
Venue: INAM meeting-room
Proceedings: Progressive Report 1
PDM Modification (Michihiko Tonouchi)
Discussion
Attendee: INAM General Director and others
JICA Mozambique Chief Representative, Senior Representative,

Project Formulation Advisor, Kota Nakai (expert) and others
JCC member DNA and others
Consultant team

3rd JCC: 7th of July 2017
Venue: INAM meeting-room
Proceeding: Progressive Report 2
Project Deliverables handover
Attendee: INAM General Director and others
JICA Mozambique Chief Representative, Senior Representative,
Project Formulation Advisor, Kota Nakai (expert) and others
JCC member DNA and others
Consultant team

Open seminar 19th of March 2018
Venue: Hotel Cardoso
Proceedings: Meteorological information/warning of INAM
Disaster Risk Reduction Activities by weather information/warning users
Project final report
Attendee: INAM General Director and others
JICA Mozambique Chief Representative, Senior Representative,
Project Formulation Advisor, Michihiko Tonouchi, Kiichi Sasaki and others

2. 5. 2 Meetings with the Director General

At the beginning and end of every on-site activity, the team held meetings with the Director General (formerly the National Director) of INAM. During these sessions, the team outlined activity plans, activity results and issues to be addressed. Details of the meetings are provided below.

[2015]

21st of April: Baseline survey plan (observation and forecast) and work plan
14th of May: Baseline survey reporting (observation and forecast)
18th of May: Baseline survey plan (radar)
5th of June: Baseline survey reporting (radar)
1st of September: Activity plan (observation)
24th of September: Activity reporting (0bservation), activity plan (radar and forecast)
30th of September: Activity reporting (radar)
14th of October: Activity reporting (forecast, to the Project Manager)

[2016]

24th of February: Activities reporting (observation)
17th of March: Activity plan (forecast)
23rd of March: WMO-day, equipment hand-over ceremony
4th of April: Activity reporting (forecast) and discussion on changing project target from radar to satellite
5th of August: Activity Plan (Traceability and observation)
26th of August: Activity reporting (traceability)
13th of September: Activity reporting (observation) and plan (forecast)
PDM modification
27th of September: Activity reporting (long term expert)
13th of October: Activity reporting (satellite and forecast, to the Project Manager)

[2017]

23rd February: Activity reporting (satellite, to the Project Manager)
6th April: Activity reporting (observation, to the Project Manager)

[2018]

14th March: Activity reporting (forecast, satellite, open seminar, to the Project Manager)
22nd March: Project final reporting (expanded NDM, to the Project Manager, DG and others)

2. 6 Short-term expert activity

Two experts in short-term activity were dispatched from JMA's RIC Tsukuba to INAM in August 2016 to conduct on-site training on inspection and calibration of meteorological instruments. They implemented exercises on the calibration of barometers and thermometers as follow-up to the Verification and Maintenance of Meteorological Instruments training implemented in Japan in 2015. An exercise on thermometer inter-comparison was also conducted on a field site of Beira Observatory. Figure 2-4 details the inter-comparison, and Table 2-6 shows the training schedule.

Explanation of intercomparison Reading thermometer Certificate of training

Fig. 2-4 Training of Intercomparison at Beira Observatory

Table 2-6 Follow-up training schedule

date			schedule	site	accommodation
31-Jul	Sun		Travel (Tokyo to Maputo)		
1-Aug	Mon		Travel (Tokyo to Maputo)		Maputo
2-Aug	Tue	AM	* Courtesy call to National Director of INAM * Kick-off meeting for training * Short tour for INAM facilities	INAM HQ	Maputo
		PM	* Country report by INAM * Lecture 1 (traceability, standards structure		
3-Aug	Wed	AM	* Exercise 1 (follow-up training for 2015 RIC Tsukuba Training, barometer)		
		PM	* Exercise 2 (follow-up training for 2015 RIC Tsukuba Training, thermometer)		
4-Aug	Thu	AM	* Lecture 2 (calibration of barometer) * Lecture 3 (calibration of thermometer)		
		PM	* Discussion1 (calibration at HQ, manuals, maintenance for standards, calibration room environment)		
5-Aug	Fri	AM	* Exercise 3 (instrument comparison with standard for local observatori		
		PM	* Discussion2 (comparison activity in local observatories)		
6-Aug	Sat		* Preparation	Maputo	Maputo
7-Aug	Sun		* Preparation		
8-Aug	Mon	AM	Travel (Maputo to Beira) * Short tour for Beira observatory	Baira	Beira
		PM	* Exercise 4 (instrument comparison with standard, barometer)		
9-Aug	Tue	AM	* Exercise 5 (instrument comparison with standard, thermometer)	Beira	Maputo
		PM	* Exercise 4 (traceability, calibration) Travel (Beira to Maputo)		
10-Aug	Wed	AM	* Discussion 3 (calibration and maintenance at HQ and observatories)	INAM HQ/ JICA	
		PM	* Final meeting with INAM and reporting for JICA Mozambique		
11-Aug	Thu		Travel (Maputo to Tokyo)		
12-Aug	Fri		Travel (Maputo to Tokyo)		

Chapter 3. Activity Results

3. 1 Output 1-a: Traceability of Meteorological Instruments

3. 1. 1 Activity Plan

(1) Project Purpose and verifiable indicators

[OUTPUT]

Capacities in meteorological observation at INAM are enhanced

[VERIFICATION]

1-1: Developed guidelines and manuals for the traceability and inspection of meteorological instruments.

1-2: Developed guidelines for the monitoring heavy rain with satellite data and ARG (Automated Rain Gauge) data.

1-3: Training on meteorological observation is conducted for at least 3 INAM staffs in charge for operational observation/calibration.

1-4: Meteorological instruments which ensure traceability of calibration are at least 80%.

(2) Activities for OUTPUT

[ACTIVITY]

1-1. Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others.

1-2. Procured traveling standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible from second calibration.

1-3. Develop guidelines for the monitoring heavy rain with satellite and ARG data and checkup list for ARG.

1-4. Develop guidelines and manuals for the traceability and inspection of meteorological instruments.

1-5. Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data.

1-6. Conduct trainings for the traceability and inspection of meteorological instruments according to guidelines and manuals based on the activity 1-4.

1-7. Conduct follow-up activities to monitor and analyze heavy rain on daily operation.

1-8. Conduct follow-up activities to establish the traceability and inspection of meteorological instruments.

3. 1. 2 Issues extracted by the baseline survey

The findings of the baseline survey conducted at the INAM Central Office, the MAPUTO airport observatory and local stations from mid-April to mid-May 2015 are outlined below.

(1) Current status of maintenance of meteorological instruments at the Central Office

Positive indications	Organization and staff assignment - The Maintenance Management Section of the Central Office manages maintenance activities and performs periodic inspections of observatories at major airports. Instruments and facilities - The Central Office is equipped with basic standard instruments for calibration and inspection facilities for barometers, thermometers and hygrometers. - The standard instruments are periodically calibrated at the national standardization office (INNOQ). Contingency plans - A SOP (standard operating procedure) for instrument failure is in place.
Issues to be addressed	Organization and staff assignment - The Maintenance and Management Section consists of a chief and seven staff. As the only meteorological instrument expert in the section, the chief handles all maintenance plans, procurement of instruments and parts, repair, testing and other related matters. - To enable appropriate task sharing within the section, it is necessary to foster the development of core technical staff and ensure a sufficient staff body for nationwide instrument maintenance. - Regular inspections are not conducted at local stations. Instruments and facilities - Calibration facilities are out of date, and some are no longer used. - The precision and number of national/travelling standards are insufficient for accurate inspection. - There is a need for high-precision standards/facilities and efforts for the transfer of maintenance and management techniques. Contingency plans - The SOP is not applied appropriately. In some cases, the Instrument Section of the Central Office did not receive instrument problem reports issued by local observatories and no action to address the issues was taken.
Causes and analysis	Organization and staff assignment

	- Various issues with INAM personnel planning were found. Personnel plan revision to foster the development of technical staff and ensure appropriate staffing numbers is required. - Inspection reports and results of calibration at stations need to be documented. Instruments and facilities - It is necessary to maintain and replace standard instruments and facilities regularly. - It is necessary to conduct training on the operation and maintenance of digital meteorological instruments. Contingency plans - Problems with instruments and facilities at stations should be reported in writing under the SOP, but in fact reporting is often conducted by telephone. - There is a need for detailed procedures relating to approval at each stage for local stations, regional offices and the Central Office.
Counter-measure	Organization and staff assignment - The expert team outlines examples from JMA, advises on appropriate INAM structure and collaborates on the establishment of such structure. - The expert team fosters the development of core technical staff via training at INAM and in Japan. Instruments and facilities - The expert team purchases new calibration equipment and important standard instruments (national/travelling standards) for nationwide maintenance under this project. - The expert team transfers maintenance and management techniques via training at INAM and in Japan. Contingency plans - The expert team advises on an appropriate procedures for INAM and collaborates on the establishment of such procedures.

(2) Current status of meteorological instrument maintenance at local stations

(Described in 3.2)

(3) Observation expertise at local stations

(Described in 3.2)

3. 1. 3 Activity details

(1) Baseline survey on traceability (April to May 2015)

As a part of the baseline survey, interviews with INAM staff handling meteorological instruments, maintenance and calibration at INAM Headquarters and several local stations were conducted from April to May 2015. The main results are summarized in 3.1.2.

The expert team conducted an inspection of the national standardization office (INNOQ) with particular focus on its calibration facilities national-standard maintenance

Fig. 3-1 INNOQ

(2) Training on traceability (September 2015)

During the second activity conducted in September 2015, documents and materials on meteorological instrument traceability and maintenance/inspection of meteorological instruments were created, and presentations were given to observation/maintenance staff at INAM Headquarters. The expert paid a visit to Xai-Xai station and conducted barometer/thermometer intercomparison with a traveling standard brought from Japan. Records of the training on traceability are shown in Table 3-1.

Fig. 3-2 Exercise (traceability)

Table 3-1 Record of presentations (traceability)

Date (2015)	Method (Location)	Details	Presenter
8 Sept.	Presentation (Central Office)	▪ Introduction to JMA's observation network - Current status of observation network - Optimal balance of manned and unmanned stations - Introduction to AWS	Koji Matsubara
10 Sept.	Presentation (Central Office)	▪ Meteorological instrument maintenance and facilities - History of surface observation in Japan	Koji Matsubara
11 Sept.	Presentation (Central Office)	▪ Meteorological instrument maintenance and facilities - Meteorological instrument maintenance at JMA - Inspection of meteorological instruments	Koji Matsubara

21 Sept.	Presentation (Central Office)	▪Traceability and standard instruments - Traceability of meteorological instruments - Standard instruments and calibration	Koji Matsubara

(3) Installation of calibration equipment and intercomparison (February 2016)

Following the second activity, a training course on verification and maintenance for meteorological instruments was held in Japan (described in Chapter. 3.8). Procured instruments including digital barometers, digital thermometers and rain gauges for INAM were calibrated at RIC Tsukuba of JMA during the training course. These instruments and a constant-temperature tank were transported to INAM at the beginning of February 2016.

During this activity, the equipment was assembled and installed with the relevant staff at INAM (Figure 3-3). Follow-up training on barometer/thermometer intercomparison and calibration was implemented. Records of the exercises conducted are shown in Table 3-2.

Unpacking equipment   Assembling devices   After bolometer training

Fig. 3-3 Installation of transported instruments and equipment

Table 3-2 Record of exercises (traceability)

(2016) 2/16	Exercise (Central Office)	▪ Unpacking/counting of standards and equipment for calibration	Koji Matsubara
2/17	Exercise (Central Office)	▪ Assembly of standards and equipment for calibration and related performance checking	Koji Matsubara
2/18	Exercise (Central Office)	▪ Calibration and intercomparison of barometers and thermometers	Koji Matsubara
2/19	Exercise (Central Office)	▪ Calibration and intercomparison of barometers and thermometers	Koji Matsubara
2/23	Exercise (Central Office)	▪ Summary of calibration and intercomparison	Koji Matsubara

The expert visited Lichinga Station and conducted a site survey to determine the current status of meteorological instruments and the performance of meteorological observation. OJT on pressure observation and intercomparison was also conducted at the site.

(4) Training on inspection and calibration by JMA short-term experts (August 2016)

On-site training on inspection and calibration of meteorological instruments was conducted by JMA experts in short-term from RIC Tsukuba at INAM Headquarters and Beira Station in early August 2016. Two RIC experts also gave follow-up presentations on barometer/thermometer calibration and intercomparison at a field site. An intercomparison exercise was additionally conducted at a Beira field site to promote the importance of ensuring the traceability of meteorological instruments at local stations.

Following the on-site training, the expert team conducted OJT on calibration of thermometers and barometers. Records of the relevant presentations and exercises are shown in Table 3-3.

Table 3-3　Record of presentations and exercises (traceability)

(2016) 8/2 - 8/9	Presentation, Exercise (Central Office) (Beira station, 8/8, 8/9)	▪ Traceability and calibration of meteorological instruments by RIC experts ▪ Thermometer intercomparison at field site ▪ Production of a pressure correction table	Kawamura, Yoshimura (RIC Tsukuba) Koji Matsubara
8/15 - 8/22	Presentation, Exercise (Central Office)	▪ Calibration of barometers and thermometers ▪ Issuance of calibration certificates ▪ Calibration of glass thermometers (traveling standard) and issuance of certification	Koji Matsubara

(5) Exercises on electronic thermometers and AWS (February to March 2017)

The 5th activity involved exercises on the inspection of electronic thermometers, mutual checking of standard barometers and AWS maintenance as a wrap-up activity regarding traceability. The electronic thermometers used for AWS differ from conventional glass thermometers in terms of the related measurement principle and specifications. The use of electronic thermometers is more common in Mozambique today, making this a good opportunity for training on related calibration and maintenance.

The relevant expert paid visits to the Beira and Nampula stations with barometer/thermometer traveling standards and checked local barometers, thermometers and hygrometers there, with results indicating appropriate maintenance. On the visit to Beira, the expert provided information on AWS and related data at Maputo, Beira and Nampula stations. The 13 staff attending the presentations demonstrated significant interest in AWS data in association with a period of heavy rain occurring from the 26th to the 28th of February just before the technical visit. Photos of the exercises are shown in Figure 3-4, and records of the presentations and exercises are shown in Table 3-4.

Calibration of electric thermometer Check of AWS data Lecture on AWS

Fig. 3-4 Calibration of AWS sensors and presentation on AWS

Table 3-4 Record of presentations and exercises (traceability)

(2017) 1/16, 1/17	Exercise (Central Office)	▪ Calibration of electronic thermometers for AWS	Kota Nakai, Kiichi Sasaki
2/13 - 2/5	Exercise (Central Office)	▪ Calibration of electronic thermometers for AWS and related summary	Koji Matsubara
3/1 - 3/3	Presentation,, Exercise (Beira, Nampula)	▪ Checking of thermometers, hygrometers and AWS thermometers as well as hygrometers at individual field stations ▪ Presentation on AWS precipitation data (Beira)	Koji Matsubara

(6) Material output relating to activities

1. Documents and materials on training relating to the traceability of meteorological instruments
2. Calibration certification for glass thermometers used in traveling standards
3. Guidelines for calibration and inspection of meteorological instruments (Draft version)

(7) Collection materials

Table 3-5 Collection materials

Title	Details	Provider
METEOROLOGIA (Portuguese edition)	Surface observation guidelines edited by INAM 'METEOROLOGIA'	Observation department, INAM
WMO No.8 (English edition)	Surface observation guidelines edited by WMO	WMO website

3. 1. 4 Issues and initiatives for further activities

(1) Working group organization

Toward achievement of the intended output and implementation of the related activities, the expert team proposed the organization of a working group (WG) to INAM. Rather than being seen only as trainees, the WG members were viewed as core members playing leading roles in post-project continuation and development of activities in this JICA project. A WG member list is shown in Table 3-6.

Table 3-6　WG members (Meteorological Observation & Maintenance)

Member	Position/department
Joaquim Ricardo Nhapulo	Meteorology Professional Technician, Instrumentalist/DMGS
Benjam Ben Manhica	Maintenance Technician/DMGS
Arsenio E. Vilanculo	Instruments Maintenance/DMGS
Ismael S. Mahazule	Technician/DON
Augusto J. Januario	Technician/DON

(2) Promotion of traceability to local stations

Review of traceability regarding meteorological instruments in developing countries indicates that, although national standards and calibration equipment are in place, the concept of traceability is not widely embraced at local stations in many countries. As the current status of Mozambique is similar, the relevant INAM supervisors should understand operational procedures for traceability and conduct OJT with local staff at every opportunity for local station inspections.

3. 1. 5　Suggestions for future work

Technical transfer relating to calibration and maintenance of barometers and thermometers at INAM were completed as a result of the three-year activity plan. In future work, INAM staff should:

- ensure the traceability of current and future conventional meteorological instruments, including those employed at AWSs;
- make efforts to ensure traceability for meteorological instruments other than barometers and thermometers;
- calibrate INAM standards at least once a year;
- maintain the traceability of other traveling standards and similar based on mutual calibration within INAM; and
- store calibration results appropriately for at least 10 years.

3. 2 Output 1-b: Surface Observation

3. 2. 1 Activity Plan

(1) Project Purpose and verifiable indicators

[OUTPUT]

Capacities in meteorological observation at INAM are enhanced

[VERIFICATION]

1-1: Developed guidelines and manuals for the traceability and inspection of meteorological instruments.

1-2: Developed guidelines for the monitoring heavy rain with satellite data and ARG (Automated Rain Gauge) data.

1-3: Training on meteorological observation is conducted for at least 3 INAM staffs in charge for operational observation/calibration.

1-4: Meteorological instruments which ensure traceability of calibration are at least 80%.

(2) Activities for OUTPUT

[ACTIVITY]

1-1. Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others.

1-2. Procured traveling standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible from second calibration.

1-3. Develop guidelines for the monitoring heavy rain with satellite and ARG data and checkup list for ARG.

1-4. Develop guidelines and manuals for the traceability and inspection of meteorological instruments.

1-5. Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data.

1-6. Conduct trainings for the traceability and inspection of meteorological instruments according to guidelines and manuals based on the activity 1-4.

1-7. Conduct follow-up activities to monitor and analyze heavy rain on daily operation.

1-8. Conduct follow-up activities to establish the traceability and inspection of meteorological instruments.

3. 2. 2 Issues identified by the baseline survey

The baseline survey conducted at the INAM Central Office, the Maputo Airport observatory and local stations identified the following issues:

(1) Current status of management on meteorological instruments at Central Office

(Described in 3.1)

(2) Current status of management on meteorological instruments at local stations

Positive indications	Organization and staff assignment - Adequate staffing for 24-hour observation was ensured at major observatories and airport observatories. Some observatories were operated by only one or two staff. - Staff allocated to observatories essentially perform observation roles including daily maintenance of facilities and instruments, such as visual inspection, cleaning, replacement of consumables and minor adjustment. Instruments and facilities - Digital/aneroid-type barometers were used at some airport observatories for comparative observation. Many observatories had only one meteorological instrument for each element. Contingency plans - Issues identified at local observatories must be reported to the Central Office.
Issues to be addressed	Organization and staff assignment - Nighttime observation is not conducted at stations operated by only one or two staff. Personnel relocation has not been implemented for a long time at local stations. - Since staff allocated to observatories essentially serve as observers, observatory maintenance is implemented by Central Office technical staff. Nationwide maintenance requires the establishment of a regional structure similar to that operated by JMA. Instruments and facilities - Due to a shortage of recording paper and consumables, data on surface observation elements such as precipitation, wind, temperature and humidity are not recorded at some observatories. - Instruments at many observatories have been inoperational and unmaintained for 10 years or more, resulting in long periods of missing data. - As regular inspections are not implemented at local stations, it is necessary to check the accuracy of observation data for barometer readings, temperature, precipitation and other variables. Contingency plans - Spare parts /instruments are not kept, resulting in observation gaps when instruments fail.

	- As maintenance is implemented only by the Central Office, significant data gaps occur.
Causes and analysis	Organization and staff assignment - As many of the issues identified appear to result from INAM human resource development and personnel allocation, clarification and revision are needed to ensure that staff are allocated to appropriate roles and locations. - The capacity of the Central Office to implement fully tailored maintenance appears limited due to the need for nationwide coverage. The implementation of a regional system similar to that operated by JMA is advisable for decentralization. Instruments and facilities - Procurement of spare parts for instruments and consumables appears to depend on INAM budget plans. - It is necessary to adopt a management system involving regular inspections for prompt detection of instrument failure. Contingency plans - Problems with instruments and facilities at stations should be reported in writing under the SOP, but in fact reporting is often conducted by telephone. - There is a need for detailed procedures relating to approval at each stage for local stations, regional offices, the Director and the Director General.
Counter measures	Organization and staff assignment - The expert team advises on appropriate INAM structure for the smooth provision of meteorological observation services, and collaborates on the establishment of such structure. - The expert team highlights JMA's regional system, advises on appropriate INAM structure and collaborates on the establishment of such structure. Instruments and facilities - The expert team procures new calibration equipment and important standard instruments (national/travelling standards) and conducts training on techniques for comparison at observatories. - The expert team recommends the use of digital meteorological instruments for major and minor observations, and considers ways to reduce the burdens of observers at local stations.

	Contingency plans - The expert team advises on appropriate INAM structure via training on site and in Japan, and collaborates on related system development.

(3) Observation expertise at local stations

Positive indications	Manuals and training program - INAM's Meteorologia surface observation manual (1979) and its translated WMO surface observation manual (1970) are used at all observatories and in training for new staff. - All new staff undergo training and are dispatched to main observatories for around six months for OJT. Observation expertise - Observers perform surface observation based on Meteorologia. Meteorological instruments - Digital instruments such as barometers, thermometers and hygrometers are present at some observatories, but most operate conventional instruments and perform visual observation. Automatization of observation - AWOSs (automatic weather observation stations) are present at the main airport observatories. Data collected at such stations are used both for surface observation purposes and in the provision of aviation weather services.
Issues to be addressed	Manuals and training - Meteorologia was published around 30 years ago, and does not address digital instruments/equipment. - INAM provides training for new staff but not for senior personnel. Observation expertise - Observation at many observatories is not conducted to schedule; one instance of observation 15 minutes early was found. - In one case, a mercury barometer was installed at the wrong height. One observer also did not know the usage of a vernier scale. - Readings were reported as observation values without the requisite correction for instrument error. Meteorological instruments

	- Many observatories had malfunctioning instruments. This was considered to result from INAM's maintenance structure. Automatization of observation - AWSs (automatic weather stations) are present at six observatories in addition to the above six AWOS observatories. However, not all AWSs are operational.
Causes and analysis	Manuals and training program - Meteorologia and other publications are used for new staff training. This content needs to be revised to create a new meteorological surface observation manual. - It is necessary to provide periodic training for senior personnel at local observatories and elsewhere to support basic expertise in surface observation and with new meteorological instruments. Observation expertise - A major issue appears to be caused by failure to follow the standard surface observation procedure prescribed in Meteorologia at local observatories. - Traceability of meteorological instruments and related adjustment should be secured. Meteorological instruments - Instrument failure was observed at numerous observatories. This was considered to stem from issues with the INAM maintenance structure. Automatization of observation - It is necessary to improve expertise on maintenance and management of automated meteorological instruments. - As comprehensive adoption of AWS operation may be impractical, installation of digital instruments and adoption of maintenance techniques for familiarization with AWS may be effective.
Counter-measure	Manuals and training - The expert team will revise Meteorologia and other surface observation manual content in conjunction with INAM. - The expert team will consider training matters, such as materials, targets, locations and terms for INAM staff. Observation expertise

	- The expert team conducts training on surface observation at the Central Office and local stations, and proposes specific, sustainable training based on such efforts. Meteorological instruments - As many of the issues identified appear to result from INAM financial planning and maintenance, revision is needed to ensure that staff are allocated to appropriate roles and locations. Efforts should be made to avoid continuing surface observation without quality assurance, and to eliminate long periods of missing data. - The expert team will engage in discussions with INAM on potential plans. Automatization of observation - The expert team conducts training to build AWS expertise and technical ability at the Central Office and local observatories, and promotes technical transfer in relation to new instruments.

3. 2. 3 Activity details and results

(1) Details of activities

As part of its baseline survey efforts, the expert team conducted interviews and investigation with personnel at the Instrument Section of Central Office on the current status and operation of INAM standard instruments and calibration equipment from April to May of 2015. During the same period, the team conducted surveys at major airport observatories and local stations on the current status of instruments, maintenance in surface observation and observation expertise.

As a continuous activity premised on the baseline survey, in September 2015 the expert team formulated documents and materials on surface observation expertise, meteorological instrument maintenance and data quality control, and conducted related training for personnel in the Maintenance and Management Division, the Observation Division and the Application Division. At the same time, the team implemented comparative observation of barometers and thermometers at major observatories with standard instruments brought from Japan.

Also as part of its continuous activities, the expert team formulated documents and materials for INAM and conducted training from August to September in 2016. INAM organized regular training on aeronautical weather observation for airport observatory staff from June to September of the same year at the Central Office. INAM’s arrangements for four classes allowed the provision of training to observers from across the country. The sessions covered (1) introduction to and usage of observation field notes, (2) basics of SYNOP observation, (3) value reading and correction, and (4) introduction to and usage of daily/weekly check notes for instrument maintenance in surface observation. A total of 38 staff from across the nation attended the training. INAM had not previously used observation field notes or daily/weekly check notes, but the expert team decided to promote their introduction in subsequent activities based on positive feedback from attendees.

The fourth and final activity was conducted from February to April 2017. In this work, the expert team revised the latest textbook and conducted training at seven local stations. The sessions were attended by 34 staff (6 of whom had taken the previous training at INAM), bringing the overall number of INAM observers taking the training to 66. The team also implemented comparative observation of barometers and thermometers against INAM standard instruments at each station they went to. The results of the intercomparison are outlined in the next section.

Lecture on surface observation Temperature observation Pressure observation

Fig.3-5 Lecture and exercise on surface observation

(2) Activity results

The activities of the expert team are as detailed below.

Table 3-7 Record of field surveying and interviews

Date (2015)	Interviewee	Activity details
April 17	Weather Forecasting Division	- Current status of weather forecasting
April 17 and 27	Instrument Section, Maintenance and Management Division	- Current status of standard instruments and calibration equipment - Current status of repair, adjustment and spare parts for instruments
April 17 and 28	Observation Division	- Current status of observation expertise and services
April 27	INNOQ (National standardization office)	- Current status and activity of the national standardization office in Mozambique - Results of meteorological instrument calibration record for meteorological standard instruments at INAM

April 23 May 8 Sept.16	Xai Xai station	- Current status of meteorological instruments - Current status of performance of observation performance and observer expertise - Barometer intercomparison - Current status of radar observation
April 24	Maputo Mavalene station (Maputo International Airport)	- Current status of AWOS and meteorological instruments - Current status of observation performance and observer expertise - Barometer intercomparison - Current status of aviation weather
May 4	Mapulanguene Station	- Current status of meteorological instruments - Current status of performance of observation and skills of observers - Intercomparison on barometer
May 6	Changalane Station	- Current status of meteorological instruments - Current status of observation performance and observer expertise - Barometer intercomparison (not implemented due to barometer theft the previous year)
May 7	Beira Station	- Current status of AWOS and meteorological instruments - Current status of observation performance and observer expertise - Barometer intercomparison - Current status of radar observation
May 11	Nampula Station	- Current status of AWOS and meteorological instruments - Current status of observation performance and observer expertise - Barometer intercomparison - Current status of upper-air observation

Table 3-8　Record of activities

Date	Method (Location)	Details of training	Attendees
(2015) Sept. 9	Presentation (Central Office)	SYNOP observation - General requirements - Instrument error - Current situation at INAM - Highlights	10

Sept. 10	Presentation (Central Office)	JMA Data quality control - Data quality control - AQC and HQC - AQC and HQC examples - Importance of data quality control	9
Sept.11	Presentation (Central Office)	Instruments involving uncertainty - Concept of meteorological instrument uncertainty	8
Sept.21	Presentation (Central Office)	Observatory and site conditions - General requirements - Siting classification - Minimum observatory requirements	16
(2016) Aug. 29	Presentation and Practice (Central Office)	Observation Field Note - Introduction to Observation Field Note - Observation Field Note usage - Observation Field Note and 'Observations recording sheets at stations	39
Aug. 31	Presentation (Central Office)	Basics of SYNOP Observation - Key points of SYNOP Observation - Instrument installation conditions	37
Sept. 5	Presentation (Central Office)	Value reading and correction - Thermometer reading and correction - Barometer reading and vernier scale usage - Barometer value correction	38
Sept. 12	Presentation (Central Office)	Instrument Maintenance for Surface Observation - Daily checking -- Visual inspection -- - Weekly/monthly maintenance -- Cleaning and Supplies – - Barometer/thermometer intercomparison	36
(2017) March 2	Presentation and Practice (Beira station)	Observation Field Note Basics of SYNOP Observation Value reading and correction Instrument Maintenance for Surface Observation Barometer/thermometer intercomparison	13
March 10	Presentation and Practice (Beira station)	As above	1

March 15	Presentation and Practice (Beira station)	As above	4
March 16	Presentation and Practice (Beira station)	As above	5
March 22	Presentation and Practice (Beira station)	As above	1
March 29	Presentation and Practice (Beira station)	As above	8
March 30	Presentation and Practice (Beira station)	As above	2

(3) Results of barometer/thermometer intercomparison at INAM local stations

(3)-1 Barometer intercomparison

Station barometer intercomparison was conducted via the following method:

- Compare the station barometer with the INAM working standard barometer (Working-1).
- Set the standard barometer with the same conditions as the station barometer (at the same height).
- Read five (or three) values every 3 minutes.
- Omit index correction.
- Use the correction values (Table A) locally applied at the station.
- Calculate the average of differences to determine index error.

Table 3-9 Results of barometer intercomparison

Date	Station	Index Error	Barometer status
(2015) May 7	Beira	-1.33 hPa	- Mercury barometer for daily operation - The index error is above the criterion (+- 0.7 hPa). - The station barometer is maintained every year by the Central Office. - Upgrading to digital barometers at airport stations is advisable.

		-0.11	- Vaisala digital barometers originally have high precision. - The index error is very small. - As the station barometer has not been maintained for a long time, calibration is needed.
(2016) Feb. 21	Lichinga	-0.25	- The index error is below the criterion. - As the station barometer has not been maintained for a long time, servicing and cleaning are needed.
Sept. 9	Xai Xai	-0.92	- Mercury barometer for daily operation - The index error is above the criterion. - The station barometer is maintained every year by the Central Office. - As this is a major INAM station, upgrading to digital barometer equipment is advisable.
		+0.76	- The Davis digital barometer used in the compact weather observation system does not have high precision. - The index error is slightly above the criterion.
(2017) Mar.10 (AM)	Changalane	-2.78	- The index error is above the criterion. - As the station barometer has not been maintained for a long time, servicing and cleaning are needed.
Mar. 14	Inhambane airport	+4.70	- The index error is above the criterion and unstable. - The station barometer should be replaced immediately. - Upgrading to digital barometers at airport stations is advisable.
Mar. 15		+1.77	
Mar.16 (AM)		-2.53	
Mar.16 (PM)		+2.27	
Mar. 14	Inhambane	+1.10	- The index error is slightly above the criterion. - As the station barometer has not been maintained for a long time, servicing and cleaning are needed.
Mar. 15	Panda	-0.09	- The index error is very small. - As the station barometer has not been maintained for a long time, servicing and cleaning are needed.

Mar. 22	Mapulanguene	-1.51	- The index error is slightly above the criterion. - As the station barometer has not been maintained for a long time, servicing and cleaning are needed.
Mar. 29	Nampula	-0.50	- The index error is below the criterion. - The station barometer is maintained every year by the Central Office. - Upgrading to digital barometers at airport stations is advisable.
Mar. 30	Lumbo	-1.01	- The index error is slightly above the criterion. - As the station barometer has not been maintained for a long time, servicing and cleaning are needed.

(3)-2 Thermometer intercomparison (dry-bulb type)

Station thermometer intercomparison was conducted as follows:

- Compare the station thermometer with the INAM working standard thermometer (Working-2).
- Set the standard thermometer in the same Stevenson screen.
- Read five (or three) values every 2 minutes.
- Omit index correction.
- Calculate the average of differences to determine index error.

Table 3-10　Results of thermometer intercomparison

Date	Station	Index Error	Thermometer status
(2015) Mar. 1	Beira	+0.05℃	- The index error is below the criterion (+- 0.2°C). - This thermometer can be used.
(2017) Mar. 10	Changalane	+0.02	- The index error is below the criterion. - This thermometer can be used.
Mar. 14	Inhambane	+0.34	- The index error is slightly above the criterion. - The station thermometer should be replaced for more precise observation if possible.
Mar. 15	Panda	+0.10	- Index error is smaller than the criterion. - This thermometer is possible to be used.
Mar. 21	Mapulanguene	+0.10	The index error is below the criterion. - This thermometer can be used.

Mar. 29	Nampula	+0.26	- The index error is below the criterion. - This thermometer can be used.
Mar. 30	Lumbo	+0.38	- The index error is slightly above the criterion. - The station thermometer should be replaced for more precise observation if possible.

(4) Output materials of activities

1. Documents and materials for training on the surface observation
2. Meteorological equipment maintenance manual (Draft version)

(5) Material output relating to activities

Table 3-11　Collection materials

Title	Details	Source
METEOROLOGIA (Portuguese edition)	Surface observation guidelines edited by INAM	INAM Observation Division
INAM surface observatory list	INAM surface observatory metadata list	As above
WMO No.8 (English edition)	Surface observation guidelines edited by WMO	WMO web site
INAM WMO-registered surface observatory list	INAM surface observatory metadata list	As above

3. 2. 4 Technical transfer outcomes

(1) Introduction of Field Observation Note

The expert visited a number of INAM stations during the baseline survey and determined the current status of SYNOP observations there.

Some observers were found to memorize data on all elements of observation, such as:

- Dry bulb temperature
- Wet bulb temperature
- Maximum temperature
- Minimum temperature
- Wind direction
- Wind speed
- Precipitation
- Present weather
- Cloud status
- Visibility ……………….

Some observers take memorandum about all/ some elements of observation on the slip of paper. Other observers write all/ some elements of observation on his/ her flat of the hand /or back of the hand. Then after coming back to the office, they transcribe all values in the official Observation Record Sheet. In this method, if there is a mistrustful value, the observer in the relevant station cannot confirm/ verify the mistrustful values.

The expert proposed to use Field Observation Note as one way in order to avoid a human caused error, and conducted a training on the purpose and merit of the Note. The observers in the regional stations agreed and accepted to use and there was no opposite opinion to use this note, so he expert informed this result to his C/P (the project manager, the head of observation department and the head of maintenance department). Furthermore, the expert provided sample books and the source file of this note and received a commitment from the C/P to promote (publish and deliver) this note on INAM's head.

(2) Introduction of daily/weekly check notes

All INAM observers appeared to check the status of meteorological instruments at the time of SYNOP observation, but the expert was unable to find any records on instrument status. Accordingly, there was no information on when and how instruments were damaged.

The expert proposed the use of daily/weekly check notes to record instrument status and conducted training on their purposes and benefits. The local station observers involved unanimously agreed to use these notes, and the expert reported this result to the relevant C/P staff (the project manager, the head of the Observation Department and the head of the Maintenance Department). The expert also provided sample books and a note template, and secured a commitment from the C/P staff to publish and deliver notes with an INAM header.

(3) Revision of Metadata list

The metadata list (containing information on station latitudes, longitudes, elevations, SYNOP observation frequency and other variables) is highly important for the operations of meteorological organizations worldwide. The list was found to be registered with the WMO website, but was not updated when stations were relocated.

INAM was advised to use Google Earth to pinpoint INAM stations on the website and extract station data such as latitude, longitude and elevation. Related operations remain ongoing.

(4) Provision of Software

The operational barometers currently used by INAM to determine air pressure are mercury-based. Such barometers must be used in conjunction with correction tables because mercury expands/contracts with temperature and its weight varies with gravity acceleration. The mean sea level pressure values used in SYNOP reports also require the use of a conversion table relating to elevation. All INAM stations were found to use such tables, but their formats were inconsistent and credibility varied.

Accordingly, computer resources were developed and provided to INAM as outlined below. The JICA project team advised INAM to authorize the use of these resources and promote their application in daily observation at all INAM meteorological station.

(4-1) Excel file for Table A creation

This file is used to create barometer correction Table A (for temperature and gravity) based on the simple input of station metadata (latitude, longitude, elevation and barometer elevation).

(4-2) Excel file for Table B creation

This file is used to create barometer correction Table B (for mean sea level pressure) based on the simple input of station metadata (latitude, longitude, elevation and barometer elevation).

3. 2. 5 Issues to be addressed and developments based on activities

(1) Retraining on basic matters

Basic matters regarding WMO-compliant SYNOP observation are detailed in INAM’s Meteorologia guidance. However, the results of the baseline survey indicated that instrument installation conditions/reading methods, observation times, correction of recorded values and other considerations did not comply with the guidelines.

Accordingly, materials on the basics of SYNOP observation were developed and training was provided for staff at the Central Office and remote stations to promote compliance with the guidance.

(2) Technical Working Group

The expert team asked INAM to nominate technical working group (WG) members to attend training and serve as core members acceding to the output of the project.

Table 3-12　WG member (Meteorological Observation & Maintenance)

Name	Position/department
Mr. Joaquim Ricardo Nhapulo	Meteorology Professional Technician, Instrumentalist/DMGS
Mr. Benjam Ben Manhica	Maintenance Technician/DMGS
Mr. Arsenio E. Vilanculo	Instruments Maintenance/DMGS
Mr. Ismael S. Mahazule	Technician/DON
Mr. Augusto J. Januario	Technician/DON
Mr. Andre Alberto Cambula	IT Technician/DIT

3. 2. 6　Suggestions for future work

The activities are expected to produce the outcomes detailed below in areas including the development of manual content and guidelines, training on instrument maintenance, and capacity building.

- The traceability of INAM standard/operational instruments will be improved.
- The precision of observation will be improved, which will contribute to QPE as an outcome of Output 2.
- The work will contribute to severe-storm forecasting in Mozambique and South-East Africa.
- Precise observation will contribute to the WWW program promoted by WMO.
- Precise observation will also contribute to improved GSM prediction by JMA and organizations in other countries.

3. 3 Output 1-c: Radar Observation

3. 3. 1 Activity Plan

(1) Project Purpose and verifiable indicators

[OUTPUT]

Capacities in meteorological observation at INAM are enhanced

[VRIFICATION]

1-1: Developed guidelines and manuals for the traceability and inspection of meteorological instruments.

1-2: Developed guidelines for the quality control of meteorological radar data and checkup list for meteorological radar (original).

1-3: Training on meteorological observation is conducted for at least 3 INAM staffs in charge for operational observation/calibration.

1-4: Meteorological instruments which ensure traceability of calibration are at least 80%.

(2) Activities for OUTPUT

[ACTIVITY]

1-1. Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others.

1-2. Procured traveling standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible from second calibration.

1-3. Develop guidelines for the quality control of meteorological radar data and checkup list for meteorological radar (original).

1-4. Develop guidelines and manuals for the traceability and inspection of meteorological instruments

1-5. Conduct trainings for the quality control of meteorological radar data and checkup for meteorological radar according to guidelines and checkup list based on the activity 1-3 (original).

1-6. Conduct trainings for the traceability and inspection of meteorological instruments according to guidelines and manuals based on the activity 1-4.

1-7. Conduct follow-up activities to establish the quality control of meteorological radar data and checkup for meteorological radar (original).

1-8. Conduct follow-up activities to establish the traceability and inspection of meteorological instruments.

3. 3. 2 Details of activities

The radars at the Beira and Xai-Xai sites were not operational during the baseline survey, and investigation of problems for recovery remained insufficient. Accordingly, two radar experts (Masaru Wakabayashi for hardware, Masahiro Nagashima for software) conducted detailed field surveys at both sites and at INAM Headquarters from September to October 2016.

(1) Current status of Beira radar

The expert team conducted field surveys at the Beira radar site from the 16th to the 19th of September 2016. The results were as follows:

a) Radar site

- Repairs for the radar house and the antenna tower sponsored by the telecom operator Vodacom have been made, and its appearance has changed significantly since the previous visit. The Beira radar is shown in Fig. 3-6.
- The inside of the site and spare parts were better organized than before.

Fig.3-6　Beira Radar

b) Power supply system

- To identify power supply inconsistencies, related causes and the quality of the electric voltage provided, the expert team monitored electrical conditions with a clamp-on power logger over a period of three days.

c) Transmission of radar data

- The existing transmission line had reliability issues, and radar data were sometimes not transmitted to INAM.
- INAM should choose the most reliable of Mozambique’s four telecom companies (MCL, TDM, Vodacom and Mobitel).

d) Radar display terminal

- The radar workstation and maintenance PC in the radar house were out of order and had been sent to INAM Headquarters for repair.

e) Measuring instruments and spare parts

- The results of the baseline survey revealed that tools and supplies necessary for regular check-ups and maintenance were not present on site. During the field survey, the expert team found several spare parts, including items for many devices and a magnetron oscillator, but the inventory appeared rather old.

f) Rehabilitation program with WB funding

- Waveguide and pressurization equipment had been replaced and power supply equipment had been improved under the review program with WB funding. However, UPS for power supply stabilization malfunctioned in November 2014, and electrical cables in the power distribution board had been disconnected.

g) Antenna tower cable

- The protection cover of the ladder on the antenna tower was displaced, probably due to strong winds.

Electric power substation　　Radar ladder　　Power distribution board

Fig. 3-7　Facilities of Beira Radar

(2) Current status of XaiXai radar

The expert team conducted a field survey at the Xai-Xai radar site from the 23rd to the 24th of September 2016. The results are outlined below.

a) Radar site

- The radar house, built in 2004, had sustained significant corrosion and damage likely caused by salt in humid sea winds.
- The entrance gate to the radar house was non-functional due to corrosion and damage.
- Windows in the radar room were broken.

Fig.3-8　XaiXai Radar

b) Primary power supply system

- The high-voltage power supply cable from the electric company had been removed from the radar site at the time of the baseline survey. It was found in the field survey that a cable had been connected underground from a distant power pole to the electric power substation by the electric company.
- One of the high-power resistors connected to the three-phase AC input power cable had burned out and been removed. As the station's budget would not cover the procurement of a replacement, the supply had been stopped by the power company.
- The voltage of the commercial power supply was monitored with a crank-on power logger for two days to check its stability and quality. The supply of three-phase AC power was confirmed.

c) Measuring instruments and spare parts

- Spare parts and accessories provided by the radar manufacturer in 2004 were found in several cardboard boxes in the radar house. These parts should be checked for usability, as almost 10 years have passed since installation.

Electric power substation AC power supply check

Fig. 3-9 Power supply check at the XaiXai Radar

(3) Radar display terminal at INAM headquarters

The expert team conducted a survey on radar data stored in the display terminal at INAM headquarters. Results of the survey were as follows.

a) Radar data stored in the terminal

- The previous radar observation periods were the 21st to the 26th of Feb. 2010 (continuous) and the 2nd of Feb. to the 25th of May 2015 (discontinuous). Product types were PPI, MAX, CAPPI, TOPS, VVP and SRI.

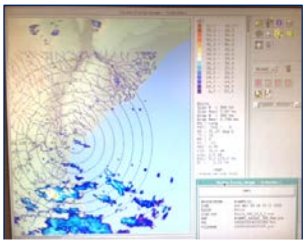


Fig. 3-10 Radar data

b) Consideration of radar data

- Strong interference in the SW and SE directions was found in most stored radar data, and sea clutter was often found in the SSE direction within the 50 – 100 km range. These influences need to be filtered out effectively via approaches such as changing the radar frequency.
- Analysis of stored radar data indicated radar’s ability to determine the intensity and movement of rain echoes even when interference waves and sea clutter are present

3. 3. 3 Radar recommendations

Although some problems affecting the Beira and Xai-Xai radars had been fixed by Gematronics, a number of issues remained, including the need for software updates supporting 24-hour operation. The ongoing instability of the radar power supply was also found to impair the performance of radar and related equipment.

Radar facilities at Xai-Xai were found to have no power supply, making 24-hour operation impractical. Such facilities at Beira were affected by similar problems, but resolution based on in-house power generation or similar appeared possible. Accordingly, the expert team advised INAM and JICA Mozambique to focus on a review of Beira radar in future work. The proposal is summarized in Table 3-13.

Table 3-13 Beira radar review proposals

	Consideration	Findings	Proposal
1	Power electricity	A more stable power supply should be secured. The UPS was non-operational.	A substation should be set on the radar site. The UPS should be updated, and an automatic voltage regulator should be installed.
2	RADAR controller and product display for radar data	The only monitor is at INAM HQ. Radar controller and product display facilities should also be provided on site.	The Gematronics estimate for monitor provision is 260,000 EUR.
3	Data communication	Data dispatch to INAM HQ is sometimes not possible.	Consider changing line 1 operation to a more reliable communications carrier.
4	Maintenance equipment	Maintenance equipment is inadequate.	If term '1' is implemented, JICA may support equipment provision.
5	Spare parts	Magnetron, PCB and devices are present.	As per item 4.

To enable the resumption of Beira radar operations and radar monitoring at INAM Headquarters, the expert team recommended that radar software, signal processors, control processors and receivers should be replaced for full-scale operation (Fig. 3-11). Communication between Beira and Maputo should also be improved to ensure stable data transmission to INAM Headquarters on a real-time basis.

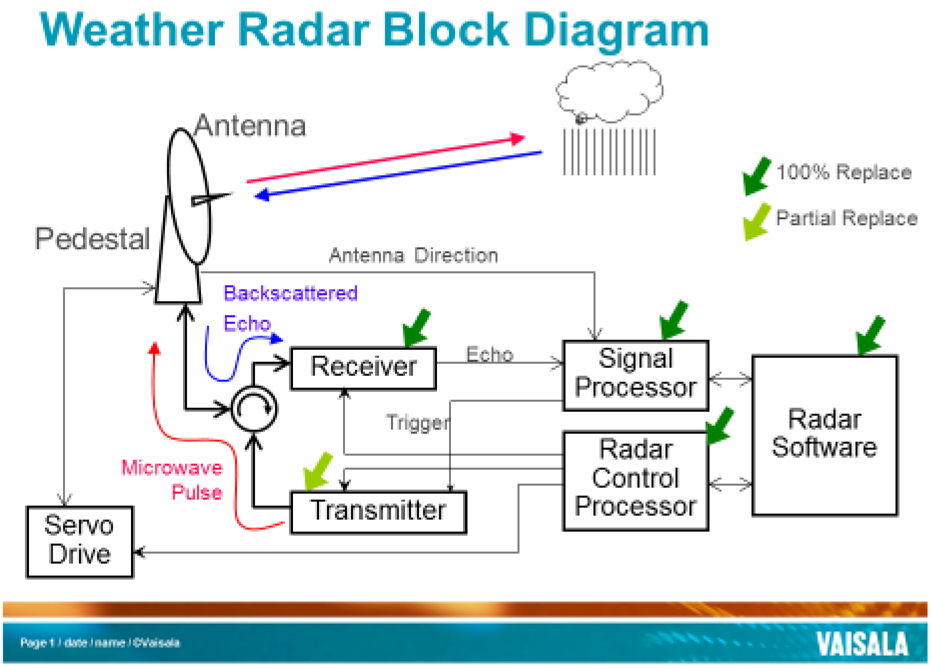


Fig. 3-11 Suggested changes based on Beira radar review

3. 3. 4 Change of the project purpose associated with the delay in radar rehabilitation

Output activities including training on radar operation and maintenance were agreed under the assumption that the meteorological radar system for at least one site would be functional. However, there were no operational radar facilities in Mozambique as of October 2015. The current status of the Beira and Xai-Xai radars was reported to INAM, and it was made clear that radar-related technical transfer should be removed from the project output if no improvement is made with points 1 and 2 in Table 3-13.

The expert team's recommendation based on the review of Beira radar from the detailed field survey conducted from September to October in 2015 encouraged INAM to have the electric company improve the power supply.

The following progress was identified during the on-site activity at Beira in March 2016:

- Commercial power was supplied to the radar site, but the necessary substation-related improvement proposed by the team had not been implemented.
- The dysfunctional UPS had been replaced, but a condenser malfunctioned during Koji Matsubara's technical visit to Beira and the UPS again became dysfunctional.

The project team outlined the following context and proposed a change in the focus of technical transfer from weather radar to satellite analysis at the National Director meeting on the 4th of April 2016. The meeting agreed to the proposal:

- It was considered impractical to conduct a review of the Beira and Xai-Xai radars and related technical transfer during the project period.
- Real-time precipitation estimation with satellite (EUMETSAT) data offers an alternative to radar for the accomplishment of Output 1.
- While heavy-rain monitoring for weather forecasting and warnings in Japan is generally carried out with radars, satellite information is also essential for monitoring in marine areas and places outside the range of radar coverage.

3. 4 Output 1-d: Meteorological satellite observation

3. 4. 1 Activity Plan

(1) Project Purpose and verifiable indicators

[OUTPUT]

Capacities in meteorological observation at INAM are enhanced

[VERIFICATION]

1-1: Developed guidelines and manuals for the traceability and inspection of meteorological instruments.

1-2: Developed guidelines for the monitoring heavy rain with satellite data and ARG (Automated Rain Gauge) data.

1-3: Training on meteorological observation is conducted for at least 3 INAM staffs in charge for operational observation/calibration.

1-4: Meteorological instruments which ensure traceability of calibration are at least 80%.

(2) Activities for OUTPUT

[ACTIVITY]

1-1. Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others.

1-2. Procured traveling standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible from second calibration.

1-3. Develop guidelines for the monitoring heavy rain with satellite and ARG data and checkup list for ARG.

1-4. Develop guidelines and manuals for the traceability and inspection of meteorological instruments.

1-5. Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data.

1-6. Conduct trainings for the traceability and inspection of meteorological instruments according to guidelines and manuals based on the activity 1-4.

1-7. Conduct follow-up activities to monitor and analyze heavy rain on daily operation.

1-8. Conduct follow-up activities to establish the traceability and inspection of meteorological instruments.

3. 4. 2 Issues found during the 1st activity

During the first visit from September to October 2016, the expert engaged in extensive discussions with INAM forecasters on satellite facilities and data for their weather forecasting in the forecasting room. Issues identified from these discussions are summarized below.

Positive indications	･ The forecasting room is equipped with the Synergy system for receiving satellite data and NWP data via satellite communications. Forecasters are able to view METEOSAT cloud images and a variety of NWP products in real time. ･ Satellite-based QPE products from the South African Weather Service's RSMC Pretoria are used for heavy-rain monitoring.
Issues to be addressed	･ The Synergy system occasionally malfunctions due to unidentified issues, resulting in significant gaps in satellite data. This causes problems in work relating to operational heavy-rain monitoring. ･ Satellite-based QPE products must be calibrated against ground-based observation information such as rain gauge data. However, only 24-hour cumulative precipitation data for periods starting at 8 a.m. are available. ･ Forecasting techniques involving the use of ARG, satellite and GPV data are not employed at INAM. ･ Post-analysis of heavy-rain events using satellite data is not conducted routinely. ･ Storage of satellite and GPV data is insufficient..
Causes and analysis	･ As the cause of Synergy system failure is not identifiable, adoption of an alternative system or review of the GTS circuit should be considered. ･ Although daily forecast operation is implemented without significant problems using RSMC products and EUMETSAT satellite data provided via the Internet, the current means of acquisition for satellite data and GPV should be improved for better forecast operation in the future.
Counter-measures	･ Introduction of the SATAID auto-downloader for EUMETSAT developed by the Japan Meteorological Agency (JMA) ･ Introduction of ARGs and acquisition of ARG data in real time ･ Training on the use of JMA-GPV and satellite data in weather forecasting and heavy-rain monitoring ･ Introduction of an auto-download system for the usage of GPV data

3. 4. 3 Activity details and results

(1) Exercise on utilization of satellite data (September to October 2016)

In response to the change of the PDM and the activity plan of the project from radar to satellite, the expert carried out the first Activity from September to October 2016. The main details and results are summarized below.

a) Technical survey on the use of satellite data

The expert conducted an interview survey with forecasters working in the operational forecasting room regarding the current status of the Synergy system, utilization of satellite data and forecast products available via the Internet. The results are summarized in 3.4.2.


Fig. 3-12 Synergy Terminal

The Synergy system had been out of operation since 2013 but became operational again in September 2016, thereby providing access to EUMETSAT data and GPV data. The details of the Synergy data were similar to those of RSMC products provided by South Africa metrological services via the Internet. Many forecasters were using RSMC products and other meteorological data available online.

b) Introduction of SATAID

The expert introduced the SATAID auto-downloader developed by JMA for EUMETSAT to Windows PCs in the operational forecasting room and elsewhere. SATAID offers a variety of useful functions such as animation of cloud images and the capacity for NWP data superimposition. The program is easy to use for operational satellite analysis and post-analysis of heavy-rain events, and can be used as backup to the Synergy system. Using the SATAID application, the expert gave presentations on satellite image analysis for a heavy rainfall event that occurred in January 2016.

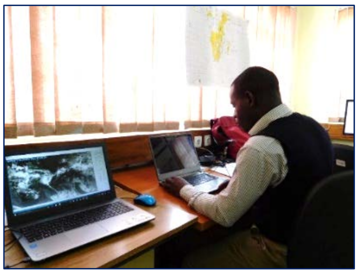


Fig. 3-13 SATAID

c) Presentation and exercise on satellite image analysis

A presentation on satellite analysis was given at INAM on 1) tropical cyclone monitoring over oceans, 2) monitoring of heavy rainfall areas where rain gauge and radar coverage is sparse, and 3) short-range weather forecasting with satellite image analysis. The expert highlighted areas of potentially heavy rainfall as a satellite-based QPE developed by JMA's Meteorological Satellite Center via SATAID application. Exercises on satellite image analysis were also conducted in relation to heavy-rain events occurring in January 2016 and Cyclone Funso in January 2012.

d) Exercise on utilization of GPV data

An exercise on utilization of GPV data was conducted for forecasters. The expert provided guidance on obtaining GPV data from JMA's GSM and visualizing the data with the GrADS program. Useful GrADS scripts were also provided for streamlined analysis and sample GPV data for future exercises.


Fig. 3-14 Exercise (GPV)

e) ARG installation

ARG (automatic rain gauge) data are indispensable for satellite-based QPE. The expert team installed three ARGs in Maputo, Beira and Nampula to check the effectiveness of the ARG network for heavy-rain monitoring.

(2) Details of 2nd activity (January to February 2017)

The expert conducted OJT for INAM forecasters during the rainy season from January to February 2017. Details of activity related to satellite data utilization are provided below.

a) Forecast OJT for heavy rain monitoring with satellite data

Presentations and exercises on utilization of SATAID for operational forecasting and post-analysis of heavy-rain events were conducted several times. As the Synergy system again malfunctioned in October 2016, SATAID was utilized not only in the exercises but also in daily weather forecasting. Heavy-rain monitoring involves analysis to determine the meteorological conditions of potential heavy-rain areas identified with SATAID using GPV data from JMA's GSM. Such areas over an ARG point were calibrated using ARG data.

● Satellite analysis for a heavy-rain event in Maputo (January 2017)

As shown in Fig. 3-15, heavy rainfall of 131 mm/24 hours in Maputo and 93.6 mm/24 hours in Xai-Xai was observed from the 15th to the 16th of January 2017, peaking in the early hours of the 16th. Figure 3-16 (left) shows satellite imagery with areas of potential heavy rain exceeding 20 mm/hour in magenta for 00 UTC on the 16th of January.

Figure 3-16 (right) shows six-hour rainfall for the period from 00 to 06 UTC on the 16th of January as estimated from EUMETSAT satellite imagery provided by the South African Weather Service's RSMC Pretoria. The cloud system over Maputo was on a small scale, and it was impractical to extract heavy-rain information from SATAID potential heavy-rain areas and satellite-based six-hour estimated precipitation data provided by RSMC Pretoria.

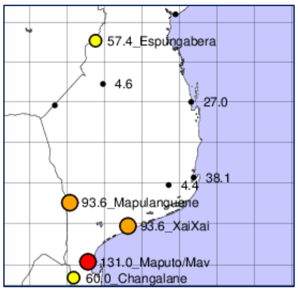


Fig. 3-15
24-hour precipitation
(15 -16 Jan. 2017)

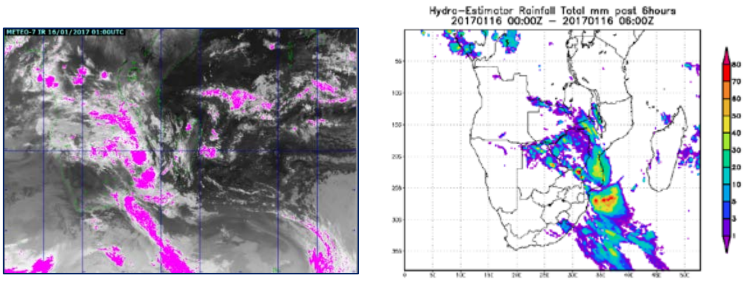
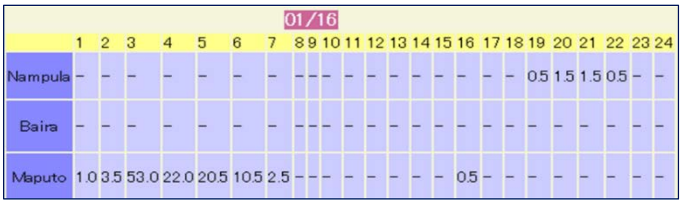


Fig. 3-16　heavy rain potential areas and satellite QPE

Figure 3-17 shows hourly ARG data from Maputo for the 16th of January. A value of 113 mm was recorded for the period covering seven hours after midnight and a maximum hourly precipitation total of 53 mm for the period between 2 and 3 a.m. The online availability of real-time ARG data makes ARG installation useful for heavy-rain monitoring with satellite data.



	01/16																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Nampula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.5	1.5	1.5	0.5	–	–
Baira	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Maputo	1.0	3.5	53.0	22.0	20.5	10.5	2.5	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–	–	–

Fig. 3-17　ARG 1-hour precipitation

(3) Material output relating to activities

- Introduction of SATAID auto-downloader for METEOSAT developed by JMA.
- Training materials on SATAID usage for heavy-rain monitoring and other purposes
- Storage of SATAID data for post-analysis of heavy-rain events

3. 4. 4　Issues and devices for further activities

The Forecast WG (Working Group) was set up in the Forecast Department to support effective provision of forecasting OJT. The expert gave presentations and conducted exercises on satellite analysis and utilization of GPV data for comprehensive weather forecasting. A list of attending WG members is provided in Table 3-14.

The Synergy system was not used during the 2016 – 2017 rainy season, and SATAID was used for daily weather forecasting. Against such a background, the expert trained duty forecasters on SATAID usage as part of forecasting OJT.

Table 3-14　List of WG members

Name	Department
Queiroz Alberto	Weather Forecast Department
Guelso Manjate	
Manuel Francisco	
Lelo Tayob	
Hipólito Cardoso	

3. 4. 5 Outcomes

From the presentations and exercises on the usage of satellite, ARG and GPV data, INAM forecasters developed a better understanding of monitoring techniques for potential heavy-rain areas using satellite and ARG data. The environment for heavy-rain monitoring was improved via the introduction of the SATAID auto-downloader and the installation of three ARGs.

3. 4. 6 Suggestions for future work

- The accuracy of satellite-based quantitative precipitation estimates is sub-optimal, and calibration with ARG data is necessary. The installation of at least one ARG in each province of Mozambique is advisable.
- Synergy system operation remains unstable; the causes of related failure should be identified or a new satellite receiving system should be installed.

3. 5 Output 2: Weather Forecast

3. 5. 1 Activity Plan

(1) Project Purpose and verifiable indicators

[OUTPUT]

Capacities in weather forecasting and warnings at INAM are enhanced.

[VERIFICATION]

2-1: At least 3 staffs of INAM obtains ability to use ground observation, ARG, satellite and GPV data for forecasting.

2-2: At least 3 staffs, in charge for operational forecast, of INAM obtains ability to operate comprehensive weather forecasting.

(2) Activities for OUTPUT

[ACTIVITY]

2-1. Conduct baseline survey and identify issues about forecasting and warning

2-2. Conduct training of weather forecasting method.

2-3. Conduct training of methodology on weather forecasting and warning by using ground weather observation, meteorological radar, satellite and GPV data.

2-4. Conduct follow-up activities to establish comprehensive weather forecast and warning by using the output of activity 2-2 and 2-3.

2-5. Conduct baseline survey to identify needs of users such as INGC, DNA, Media and private company and identify issues on weather forecast and warning product provided by INAM.

2-6. Improve weather forecast and warning base on the finding of activity

3. 5. 2 Issues found through the baseline survey

The findings of the baseline survey conducted at the INAM Central Office and several regional observatories are outlined below.

Positive indications	● At INAM Headquarters, three groups of staff work shifts covering 24-hour operation. Morning and afternoon shifts are staffed by two forecasters and one reporter, and night shifts are staffed by one reporter (during the rainy season or storm events, additional forecasters are dispatched). Three forecaster groups also work shifts covering 24-hour operation at Maputo Airport. ● Daily weather reports cover (1) 24-hour precipitation at 34 stations (starting at 8 a.m.), (2) weather and temperature forecasts for 11 cities, and (3) maximum and minimum daily temperatures for 11 cities. These reports have been stored as files

	on forecasters' PCs and in booklet form since 2014.
Issues to be improved	● The GTS communication network used for international sharing of meteorological data is unstable, and connection is often lost due to line failure between Maputo and Pretoria. During periods of such failure, INAM staff send SYNOP reports via the websites of Net-Sys (a GTS manufacturer), and INAM is unable to receive GPV data from external sources. ● INAM has a EUMETSAT receiving system (donated via the PUMA project), but is unable to use high-resolution satellite data due to de-coding key and receiving gear issues. ● At Maputo Airport, the SADIS system is out of operation due to a communication connector malfunction. ● Information required for forecasting, such as GPV/satellite data and weather charts, is generally obtained from the SAWS SWFDP website. ● Satellite data for forecasting are obtained from the EUMETSAT website. ● SADIS data are obtained from SADIS websites.
Cause and analysis	● GPV, EUMETSAT and SADIS system problems are caused by issues with communication lines and receiving systems. Close collaboration between the ITC Section and the Forecast Section is expected to improve this situation. ● Daily forecasting is implemented without major problems based on the use of SWFDP, EUMETSAT and other data via the Internet.
Counter-measure	● To enhance weather forecasting expertise, high-resolution GPV and satellite data are indispensable. Such data must be stored for at least a year to support forecast expertise training and sharing of forecasting know-how. ● PC procurement for data storage ● Automatic data storage system for weather forecast materials (extreme weather guidance, weather charts issued by SAWS, EUMETSAT satellite images (IR1, WV, VIS) and forecasts, INAM observation reports) ● Weather forecast verification activity ● Discussion of weather events and documentation of weather forecasting expertise

3. 5. 3 Activity details and results

(1) Development of data storage system (September to October 2015)

Based on the survey for actual INAM forecast operation with SWFDP data from the SAWS website, the expert procured a PC for storage of weather-related data in preparation for future developments in weather guidance and installed a script-based download system. Data storage on the PC was commenced.

The data stored include:

- Information on extreme weather guidance and weather charts (analysis and forecasts) issued by SAWS and satellite images (IR1, VIS, WV) from EUMETSAT
- GPV data issued by JMA
- INAM forecasts and observation reports

The forecast team and the expert engaged in forecast evaluation using the stored data.

The procured PC is set in the INAM forecasters’ room (Fig. 3-18), and weather forecast verification is implemented by the forecast team every Tuesday. Team chief Alberto Queiroz and his colleagues began routine operation. An example of forecast verification is shown in Fig. 3-20.

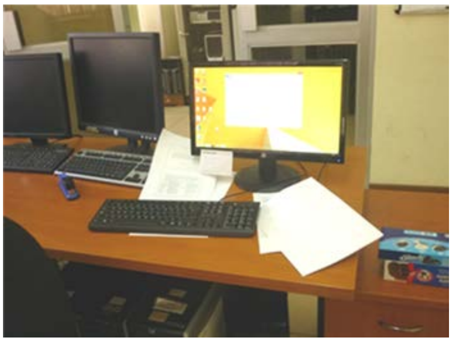


Fig. 3-18　Data storage PC

(2) Operation of data storage system (March to April 2016)

The expert confirmed the following data were automatically gathered with the data storage system and made some improvements to the system.

+ Extreme weather guidance issued by SAWS
+ Weather charts from the SAWS down-scale model (surface pressure, wind and precipitation)
+ EUMETSAT satellite images (IR1, WV, VIS)
+ JMA GPV information

From October 2015 to March 2016, repeated data storage failure occurred due to INAM network issues. As data are also stored on a PC at JMBSC, the expert brought backup data from Japan to fill in the missing data and stored the copied data on the PC at INAM as a start to the second Activity

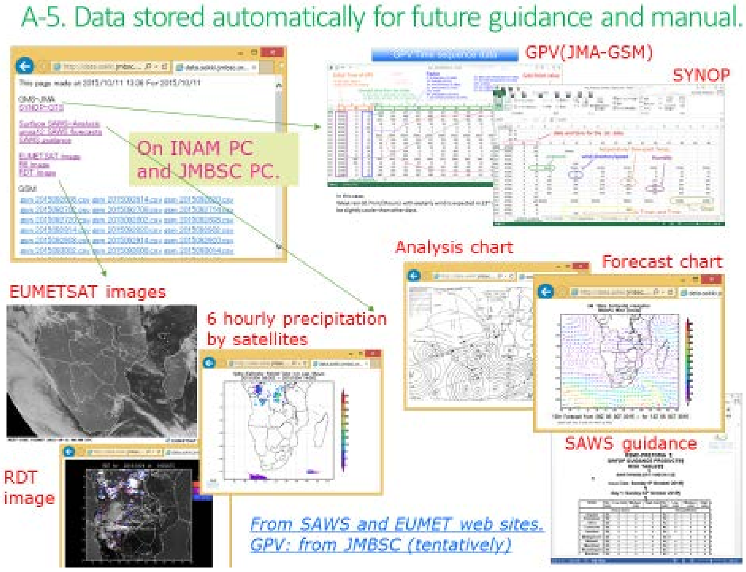


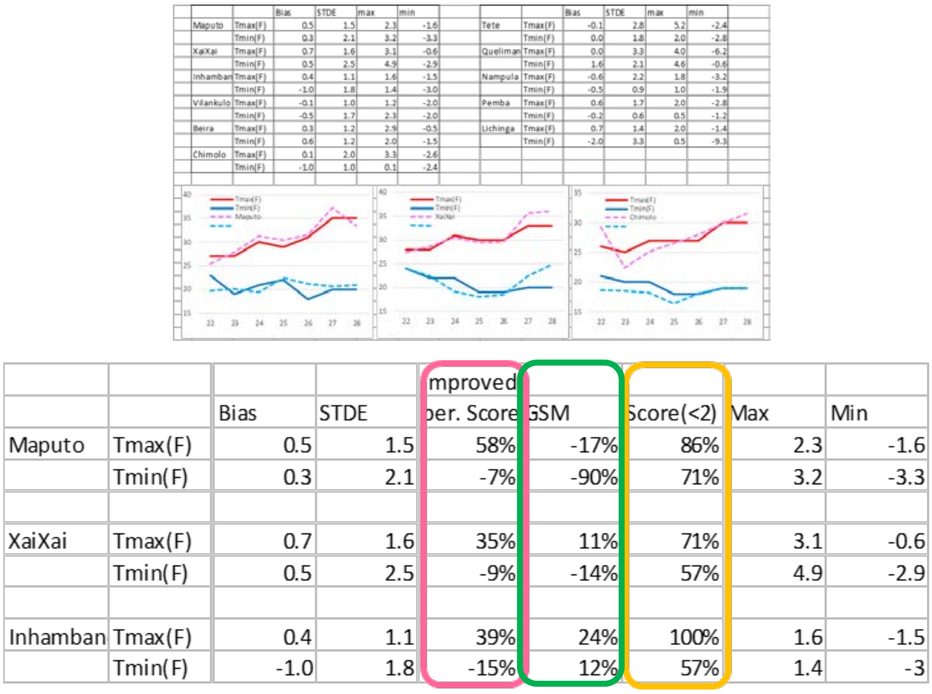
Fig. 3-19　Stored data in project PC.

(3) Weather forecast verification and monthly report (March to April 2016)

The INAM forecast team (Alberto Queiroz, Manuel Francisco and Mauro Armando) and the expert checked the weather forecast verification process. The team input forecast data (weather and temperature for 11 cities), maximum and minimum temperatures for 11 cities and 24-hour precipitation data (for periods starting at 8 a.m.) and evaluated the content against JMA-GPV data.

The MS Excel verification sheet used was designed to automatically calculate forecast verification values when temperature /precipitation observation data, INAM forecast information and GPV output are input. Verification values are the standard deviation of the difference between forecast and observation, forecast bias (average difference between forecast and observation values), expertise score (improvement ratio) against GPV/persistent forecasts and the hit rate (ratio of correct forecasts: difference between forecast and observation less than 2°C) (yellow box, Fig. 3-20).

The expert delivered presentations to the forecasters on statistical basics (e.g., standard deviation and bias), the concept of persistent forecasts and expertise score evaluation (see the report DVD for content). Some expertise scores in Fig. 3-20 are negative because weather patterns during the week in question were mostly the same and the minimum temperature did not vary.



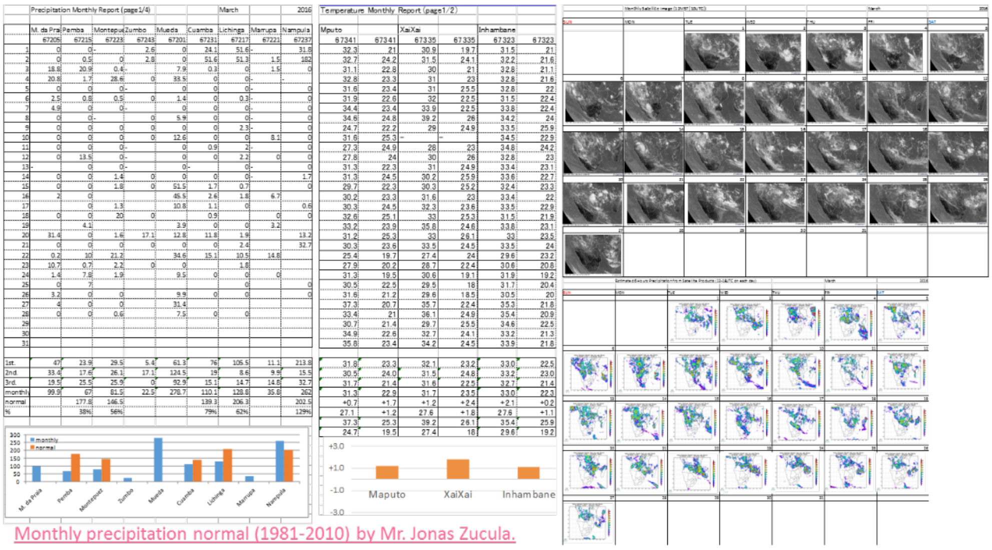
		Bias	STDE	max	min
Maputo	Tmax(F)	0.5	1.5	2.3	-1.6
	Tmin(F)	0.3	2.1	3.2	-3.3
XaiXai	Tmax(F)	0.7	1.6	3.1	-0.6
	Tmin(F)	0.5	2.5	4.9	-2.9
Inhamban	Tmax(F)	0.4	1.1	1.6	-1.5
	Tmin(F)	-1.0	1.8	1.4	-3.0
Vilankulo	Tmax(F)	-0.1	1.0	1.2	-2.0
	Tmin(F)	-0.5	1.7	2.3	-2.0
Beira	Tmax(F)	0.3	1.2	2.9	-0.5
	Tmin(F)	0.6	1.2	2.0	-1.5
Chimolo	Tmax(F)	0.1	2.0	3.3	-2.6
	Tmin(F)	-1.0	1.0	0.1	-2.4

		Bias	STDE	max	min
Tete	Tmax(F)	-0.1	2.8	5.2	-2.4
	Tmin(F)	0.0	1.8	2.0	-2.8
Queliman	Tmax(F)	0.0	3.3	4.0	-6.2
	Tmin(F)	1.6	2.1	4.6	-0.6
Nampula	Tmax(F)	-0.6	2.2	1.8	-3.2
	Tmin(F)	-0.5	0.9	1.0	-1.9
Pemba	Tmax(F)	0.6	1.7	2.0	-2.8
	Tmin(F)	-0.2	0.6	0.5	-1.2
Lichinga	Tmax(F)	0.7	1.4	2.0	-1.4
	Tmin(F)	-2.0	3.3	0.5	-9.3

				mproved				
		Bias	STDE	per. Score	GSM	Score(<2)	Max	Min
Maputo	Tmax(F)	0.5	1.5	58%	-17%	86%	2.3	-1.6
	Tmin(F)	0.3	2.1	-7%	-90%	71%	3.2	-3.3
XaiXai	Tmax(F)	0.7	1.6	35%	11%	71%	3.1	-0.6
	Tmin(F)	0.5	2.5	-9%	-14%	57%	4.9	-2.9
Inhamban	Tmax(F)	0.4	1.1	39%	24%	100%	1.6	-1.5
	Tmin(F)	-1.0	1.8	-15%	12%	57%	1.4	-3

Fig. 3-20 Weather forecast verification.

Additionally, the team engaged in an exercise involving the production of a monthly report on an experimental basis using temperature/precipitation observation data, stored satellite data and other information. The report included comparison with normals (i.e., averages for the 30-year period from 1981 to 2010), and was provided by Jonas Zucula of the INAM Climate Division.



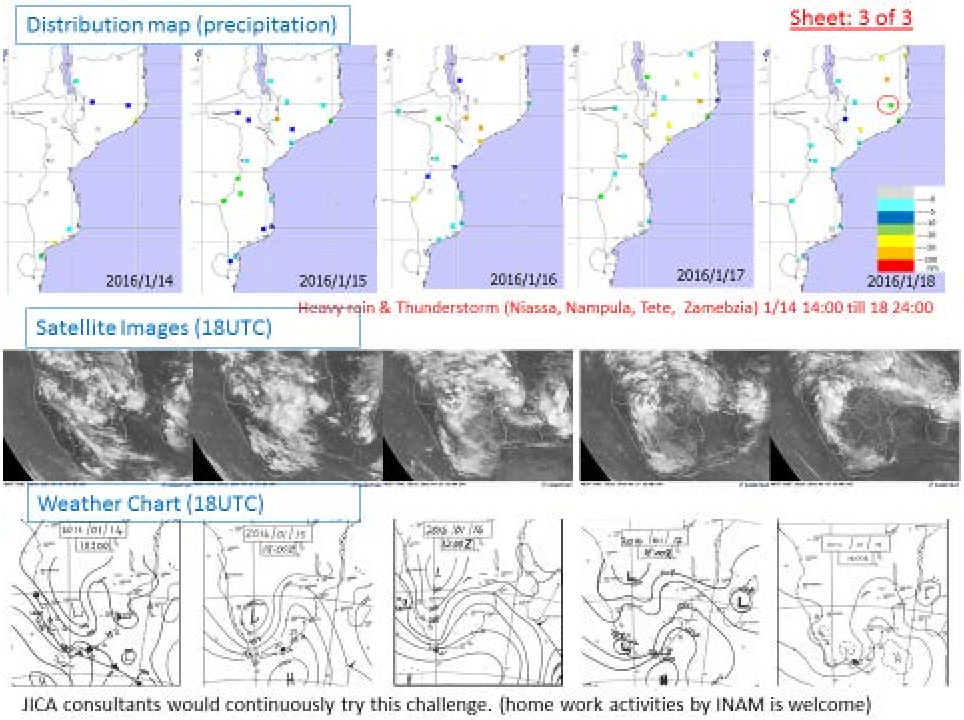
	Precipitation Monthly Report (page1/4)						March		2016
	M. da Pra	Pemba	Montepue	Zumbo	Mueda	Cuamba	Lichinga	Marrupa	Nampula
	67205	67215	67223	67243	67201	67231	67217	67221	67237
1	0	0	-	2.6	0	24.1	51.6	-	31.8
2	0	0.5	0	2.8	0	51.6	51.3	1.5	182
3	18.8	20.9	0.4	-	7.9	0.3	0	1.5	0
4	20.8	1.7	28.6	0	33.5	0	0	-	-
5	0	0	0	-	0	0	0	-	0
6	2.5	0.8	0.5	0	1.4	0	0.3	-	0
7	4.9	0	0	-	0	0	0	-	0
8	0	0	-	0	5.9	0	0	-	0
9	0	0	0	0	0	0	2.3	-	0
10	0	0	0	0	12.6	0	0	8.1	0
11	0	0	0	-	0	0.9	2	-	0
12	0	13.5	0	-	0	0	2.2	0	0
13	-	0	0	-	0	-	0	-	0
14	0	0	1.4	0	0	0	0	-	1.7
15	0	0	1.8	0	51.5	1.7	0.7		0
16	2	0			45.5	2.6	1.8	6.7	
17		0	1.3		10.8	1.1	0		0.6
18	0	0	20	0		0.9		0	0
19		4.1			3.9	0	0	3.2	
20	31.4	0	1.6	17.1	12.8	11.8	1.9		13.2
21	0	0	0	0	0	0	2.4		32.7
22	0.2	10	21.2		34.6	15.1	10.5	14.8	
23	10.7	0.7	2.2	0	0		1.8		
24	1.4	7.8	1.9		9.5	0	0	0	
25	0	7					0		0
26	3.2	0	0		9.9	0	0		0
27	4	0	0		31.4				
28	0	0	0.6		7.5	0	0		
29									
30									
31									
1st.	47	23.9	29.5	5.4	61.3	76	105.5	11.1	213.8
2nd.	33.4	17.6	26.1	17.1	124.5	19	8.6	9.9	15.5
3rd.	19.5	25.5	25.9	0	92.9	15.1	14.7	14.8	32.7
monthly	99.9	67	81.5	22.5	278.7	110.1	128.8	35.8	262
normal		177.8	146.5			139.3	206.3		202.5
%		38%	56%			79%	62%		129%

Monthly precipitation normal (1981-2010) by Mr. Jonas Zucula.

Temperature Monthly Report (page1/2)					
Mputo		XaiXai		Inhambane	
67341	67341	67335	67335	67323	67323
32.3	21	30.9	19.7	31.5	21
32.7	24.2	31.5	24.1	32.2	21.6
31.1	22.8	30	21	32.8	21.1
32.8	23.3	31	23	32.8	21.6
31.6	23.4	31	25.5	32.8	22
31.9	22.6	32	22.5	31.5	22.4
34.4	23.4	33.9	22.5	33.8	22.4
34.6	24.8	39.2	26	34.2	24
24.7	22.2	29	24.9	33.5	25.9
31.6	25.3	-	-	34.5	22.9
27.3	24.9	28	23	34.8	24.2
27.8	24	30	26	32.8	23
31.3	22.3	31	24.9	33.4	23.1
31.3	24.5	30.2	25.9	33.6	22.7
29.7	22.3	30.3	25.2	32.4	23.3
30.2	23.3	31.6	23	33.4	22
30.3	24.5	32.3	23.6	33.5	22.9
32.6	25.1	33	25.3	31.5	21.9
33.2	23.9	35.8	24.6	33.8	23.1
31.2	25.3	33	26.1	33	23.5
30.3	23.6	33.5	24.5	33.5	24
25.4	19.7	27.4	24	29.6	23.2
27.9	20.2	28.7	22.4	30.6	20.8
31.3	19.5	30.6	19.1	31.9	19.2
30.5	22.5	29.5	18	31.7	20.4
31.6	21.2	29.6	18.5	30.5	20
37.3	20.7	35.7	22.4	35.3	21.8
33.4	21	36.1	24.9	35.4	20.9
30.7	21.4	29.7	25.5	34.6	22.5
34.9	22.6	32.7	24.1	33.2	21.3
35.8	23.4	34.2	24.5	33.9	21.8
31.8	23.3	32.1	23.2	33.0	22.5
30.5	24.0	31.5	24.8	33.2	23.0
31.7	21.4	31.6	22.5	32.7	21.4
31.3	22.9	31.7	23.5	33.0	22.3
+0.7	+1.7	+1.2	+2.4	+2.1	+0.2
27.1	+1.2	27.6	+1.8	27.6	+1.1
37.3	25.3	39.2	26.1	35.4	25.9
24.7	19.5	27.4	18	29.6	19.2

Fig. 3-21 Monthly report
(precipitation, temperature, satellite and estimated precipitation)

(4) Event report and discussion (April, September to October 2016)



Distribution map (precipitation)

Sheet: 3 of 3

Heavy rain & Thunderstorm (Niassa, Nampula, Tete, Zamebzia) 1/14 14:00 till 18 24:00

Satellite Images (18UTC)

Weather Chart (18UTC)

JICA consultants would continuously try this challenge. (home work activities by INAM is welcome)

Fig. 3-22 An example for discussion of weather warning
(distribution of precipitation, satellite image, weather chart)

Based on stored information such as satellite images and observation data, forecasters discussed heavy-rain and thunderstorm warnings issued on 14th of January 2016 as summarized below.

- Heavy rain (more than 50 mm/day) was observed in the warning area, and the warning lead time was sufficient.
- Heavy rain was also observed in a province of central Mozambique outside the warning area. A warning could have been issued for central Mozambique too.
- A convergence line and a low-pressure system developed over the Mozambique Channel (between Madagascar and Mozambique), and the system brought heavy rain to the area. This is a typical pattern behind heavy rain in northern Mozambique.
- Extreme weather guidance issued by SAWS did not warn of heavy rain for Mozambique the previous day (i.e., guidance was issued on the day). Extreme weather guidance forecasted this heavy-rain event. In the March event, SAWS guidance did not forecast heavy rain correctly.

The remaining three cases of heavy-rain events were reviewed during the 3rd activity (September to October 2016). Discussions about heavy-rain events in the 2015/16 rainy season were summarized as follows:

IINAM issues daily precipitation reports (for periods starting at 8 a.m.) to related agencies and the media at 11 a.m. Based on these reports, the team examined heavy-rain events (i.e., those where daily precipitation at multiple stations exceeded 100 mm/day) and collected satellite images, weather charts, precipitation distribution maps (made by GMT with daily precipitation data) and SWFDP heavy-rain guidance issued by the South African Weather Service in April 2016.

There were four heavy-rain events during the 2015/16 rainy season, and the team had already implemented post-event analysis for the first one in April. As part of the third Activity, the team implemented post-event analysis for the other three. The analysis and discussion covered precipitation distribution, satellite image analysis, weather chart patterns and the adequacy/effectiveness of INAM warnings.

Table 3-15 Heavy-rain events in the 2015/16 rainy season

Event		Cause of heavy rain	Adequacy of warning
1	Jan. 14 – 18 2016	ICTZ and L system in Mozambique channel was enhanced	OK (warning area relatively small)
2	Jan. 25 – 30 2016	ICTZ and L system in Mozambique channel was enhanced	OK (warning area relatively small)
3	Jan. 30 – Feb. 4 2016	ICTZ enhanced, high-pressure system over southern African sea bringing warm/moist air to the Mozambique Channel	Poor (no warning issued)

4	Feb. 27 – Mar. 2 2016	Cold front enhancing meso-scale cloud clusters	Poor (issuance with 2 – 3 day lead time impractical)

INAM warnings are issued two to three days prior to forecasted heavy-rain events to allow time for dissemination to the public. Warnings for Events 1 and 2 were issued appropriately with this timing, but no warning was issued for Event 3 and issuance two to three days in advance for Event 4 was impractical.

During the discussion, it was considered that no warning was issued for Event 3 because of inappropriate hand-over from daytime to nighttime staff; in short, it was unclear which shift should issue the warning. Meanwhile, the case of Event 4 showed that even if INAM could predict heavy rain only several hours in advance, there was no way to quickly issue a warning to the public. To improve warning procedures for the situations seen with Events 3 and 4, the team planned subsequent activities as detailed below.

Event 3

During the 2016/17 rainy season, the satellite expert took part in daily forecasting activities and implemented OJT for forecasting and warning to share expertise on risk mitigation and taking warning opportunities as appropriate.

Event 4

Due to the difficulty of predicting meso-scale heavy rain with a lead time of two to three days, INAM needs a way to issue urgent warnings to the public. In northern parts of Mozambique, some areas do not receive TV signals and only local languages are spoken. Radio broadcasting should be considered for the issuance of urgent warnings to such areas.

(5) Development of a rain gauge network (October 2016)

At the 2nd JCC meeting held on the 22nd of September 2016, one of the project targets was changed from heavy-rain event observation with radar to heavy-rain event observation with satellite and AWS. Accordingly, the team procured rain gauges and ARG systems and shipped them to Mozambique for installation in Maputo, Beira and Nampula, and also procured SIM cards and contracted two years of data communication service with Vodacom. There are three major mobile phone companies (Vodacom, Mcel and Mobitel) in Mozambique, and the chief staff member (Mr. Ricard) of the INAM Observation Division identified Vodacom as the most appropriate to cover Mozambique and enable stable data communication.

Vodacom offers several monthly plans for data communication. As the volume of rain gauge data is low, the team opted for the 300 Mbyte/month plan at 300 MZN per month for each gauge, and purchased three SIM cards and two years of contract services with advance payment. The contract began on the 20th of September 2016, and required payment of 24 months of communication charges and a 1-month warranty fee. If the volume of data communication within any month exceeds 300 Mbytes, communication will be suspended until the end of the monthly period and recommenced at the beginning of the next period (the contract is shown in Appendix G). The SIM cards require a password by default; this requirement must be switched off if one of the cards is to be used for a phone.

For installation of the rain gauges, the team had to procure cement, sand and a 2-m pole for each logger box. As there was no metal grinder to cut poles in Beira and Nampula, the team performed the task with a hand saw. Supplies of these materials are scarce in local cities; procurement of materials for civil work should be considered in INAM efforts to expand AWS to such areas.

The team developed sample software to allow the display of observation data online. Such data are provided openly and monitored on the experimental website at http://data.sokki.jmbsc.or.jp/inam/.

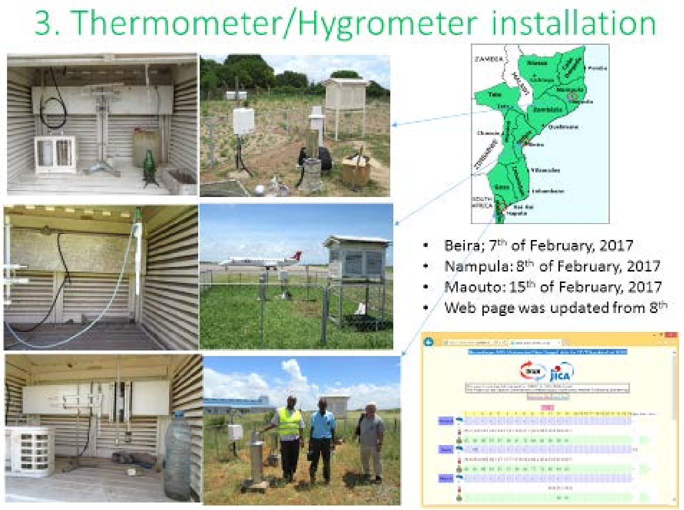
[Thermometer and hygrometer installation to the rain gauge network] (February 2017)

The team installed automatic rain gauges in Maputo, Beira and Nampula during the third Activity. During the fourth Activity, thermometers and hygrometers were added for the three stations.

The thermometer and hygrometer equipment was procured in Japan and verified by JMA. The sensors used were brought by the experts, and the thermometers were calibrated using a thermal bath with an INAM standard thermometer.

The thermometers and hygrometers were installed on the 7th, 8th and 15th of February 2017 in Beira, Nampula and Maputo, respectively, and the experimental website was modified on the 11th of February. Data are collected via TCP/IP socket communication with the JMBSC server and emailed to INAM. As the INAM network was not stable enough for continuous communication during the fourth Activity, TCP/IP data collection will be handled by JMBSC until the network is sufficiently stable. At such time, the server will be relocated to INAM (Fig. 3-24).

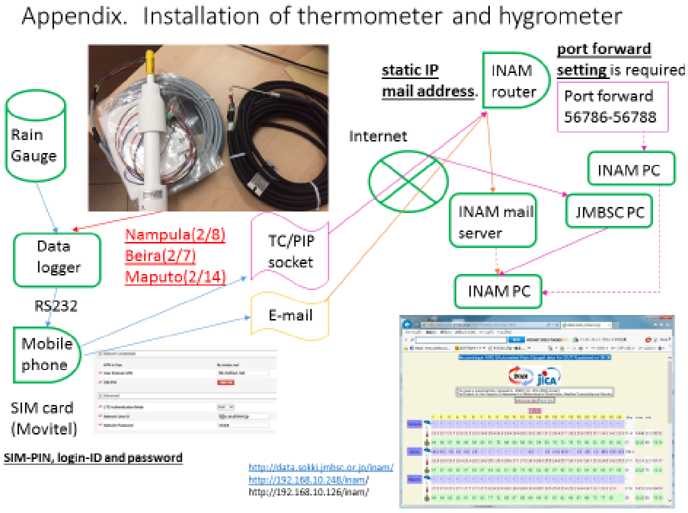
The experimental website was constructed on the JMBSC server and the INAM PCs discussed above, with these PCs being used to collect observation data from the JMBSC website for web content production. In subsequent activity, the team plans to develop web content based on data emailed to INAM.



3. Thermometer/Hygrometer installation

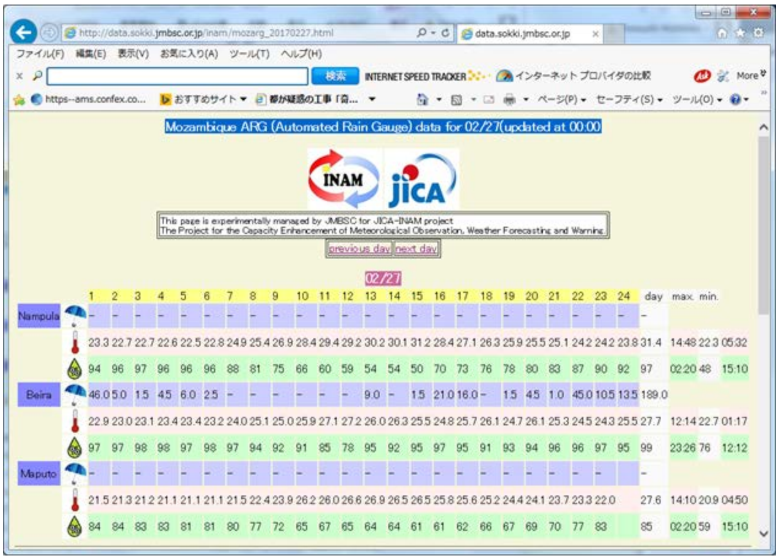
- Beira; 7th of February, 2017
- Nampula: 8th of February, 2017
- Maouto: 15th of February, 2017
- Web page was updated from 8th

Fig. 3-23 Outline of INAM-AWS



Appendix. Installation of thermometer and hygrometer

Fig. 3-24 Flow of data (INAM-AWS)



Mozambique ARG (Automated Rain Gauge) data for 02/27(updated at 00:00

This page is experimentally managed by JMBSC for JICA-INAM project
The Project for the Capacity Enhancement of Meteorological Observation, Weather Forecasting and Warning

previous day next day

02/27

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	day	max.	min.	
Nampula	☂	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
	🌡	23.3	22.7	22.7	22.6	22.5	22.8	24.9	25.4	26.9	28.4	29.4	29.2	30.2	30.1	31.2	28.4	27.1	26.3	25.9	25.5	25.1	24.2	24.2	23.8	31.4	14:48	22.3	05:32
	💧	94	96	97	96	96	96	88	81	75	66	60	59	54	54	50	70	73	76	78	80	83	87	90	92	97	02:20	48	15:10
Beira	☂	46.0	5.0	1.5	4.5	6.0	2.5	-	-	-	-	-	-	9.0	-	1.5	21.0	16.0	-	1.5	4.5	1.0	45.0	10.5	13.5	189.0			
	🌡	22.9	23.0	23.1	23.4	23.4	23.2	24.0	25.1	25.0	25.9	27.1	27.2	26.0	26.3	25.5	24.8	25.7	26.1	24.7	26.1	25.3	24.5	24.3	25.5	27.7	12:14	22.7	01:17
	💧	97	97	98	98	97	98	97	94	92	91	85	78	95	92	95	97	95	91	93	94	96	96	97	95	99	23:26	76	12:12
Maputo	☂	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-			
	🌡	21.5	21.3	21.2	21.1	21.1	21.1	21.5	22.4	23.9	26.2	26.0	26.6	26.9	26.5	26.5	25.8	25.6	25.2	24.4	24.1	23.7	23.3	22.0		27.6	14:10	20.9	04:50
	💧	84	84	83	83	81	81	80	77	72	65	67	65	64	64	61	61	62	66	67	69	70	77	83		85	02:20	59	15:10

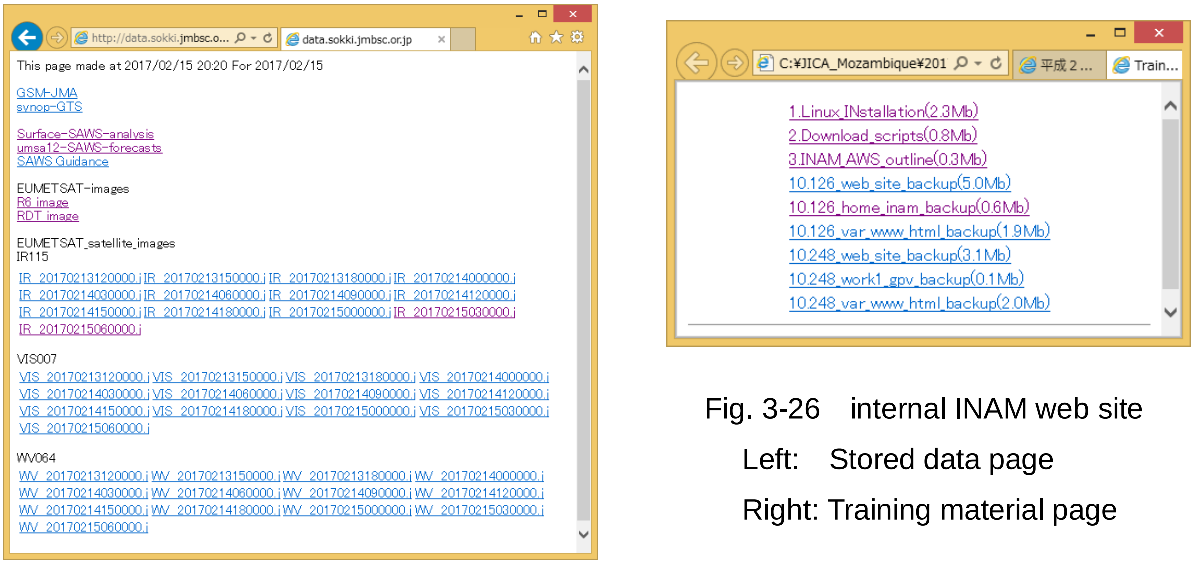
Fig. 3-25 INAM-AWS web page

(6) Exercises on Linux installation, auto-download scripts and website content (January to February 2017)

Until the third Activity, heavy-rain guidance issued by the South Africa Weather Service, weather charts, numerical weather prediction charts, six-hourly precipitation estimates based on satellite data, EUMETSAT images and JMA-GPC time-sequence forecast data were stored on a server managed by consultants in Japan, and were used for weekly forecast evaluation, event analysis and related activities. During the fourth Activity, the forecast expert installed Linux/auto-download scripts and created website content for INAM's Forecast Division and Climate Division.

This work was implemented via presentations and exercises (see the report DVD for training content) within the Forecast Division and the Climate Division, and technical expertise was transferred to Jonas Zucula and Isaias Raiva of the Climate Division and Hicardo Hiporto of the Forecast Division.

The scripts installed are automatically run for 192.168.10.126 (Climate Division) and 192.168.10.248 (Forecast Division), and PCs connected to the INAM domain can access the data.



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GSM-JMA
synop-GTS

Surface-SAWS-analysis
umsa12-SAWS-forecasts
SAWS Guidance

EUMETSAT-images
R6_image
RDT_image

EUMETSAT_satellite_images
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10.248_work1_gpv_backup(0.1Mb)
10.248_var_www_html_backup(2.0Mb)

Fig. 3-26 internal INAM web site
Left: Stored data page
Right: Training material page

(7) Presentations and exercises

1st Activity

- GPV data usage (October 7 – 8 2015)
- Basics of meteorological satellites and related usage (October 13 2015)
- Forecast evaluation (October 14 2015)
- Forecast evaluation process (October 14 2015)

2nd Activity

- Weather forecast evaluation exercises (March 22, 29, April 5 2016)
- Meteorological satellite data usage and analysis (April 6 2016)

・Heavy-rain event analysis (March 31 2016)

3rd Activity

・Heavy-rain event analysis (September 15, 20, 27 2016)

4th Activity

・Linux installation and auto-download scripts (February 2, 6, 9, 10 2017)

Collection of materials (started in October 2015; ongoing)

・INAM forest, warning, 1981 – 2010 normals

・South Africa Weather Service weather charts, NWP figures (up to 48 hours ahead), heavy-rain guidance

・EUMETSAT IR, VIS, WV satellite images

・JMA-NWP and SYNOP data

(8) Outcomes (stored on DVD and on the INAM website)

・INAM weekly forecast verification (from March 2016; weekly)

・INAM monthly report (from January 2016; monthly)

Training materials

・Meteorological satellite data usage (October 2015)

・GPV data usage (October 2015)

・Forecast evaluation 1, 2, 3 (October 2015)

・Procedure for INAM forecast evaluation (October 2015)

・Procedure for INAM monthly reports (March 2016)

・Usage of GMT (April 2016)

・2015/16 heavy-rain event reports (April/October 2016)

・Linux installation (February 2017)

・Downloading of scripts (February 2017)

・Website construction and related structure (February 2017)

(9) Outcome of technical expertise transfer

・ Weekly verification for INAM forecasts was commenced and operationally implemented.

・ Three AWSs were installed at principal airports in Mozambique, and real-time observation was commenced.

・ The provision of satellite/AWS/forecasting training and forecast OJT training by the satellite expert helped to enhance INAM weather analysis and forecast expertise. INAM issued an accurate cyclone landfall warning to the public with sufficient lead time in February 2017.

3. 5. 4 Satellite-expert activity details and results

(1) Forecast OJT during the 2016/17 rainy season (Satellite expert: January to February 2016)

The satellite expert conducted OJT for INAM staff in the forecasting operation room during the 2016/2017 rainy season as detailed below.

(a) Forecast briefing with large screen display

As part of the OJT, a forecast briefing was begun on the 6th of February 2017 with a large screen display provided by JICA. The briefing was evaluated highly by forecasters, especially in relation to Cyclone Dineo. The timely issuance of cyclone information and warnings to disaster prevention authorities and the media proved quite effective.

Fig. 3-27 Forecast briefing

- <u>Forecasting of Cyclone Dineo</u>

On the 13th of February, just a week after forecast briefings were commenced, a tropical depression formed over the Mozambique Channel and developed into a tropical storm named Dineo on the same day before developing into a tropical cyclone on the 15th near the southern coast of Mozambique as shown in Fig. 3-28. INAM forecasters and the expert paid attention to the cyclone from the beginning of its generation onward, monitored its development and movement with satellite and NWP data, and issued cyclone information and warnings promptly.

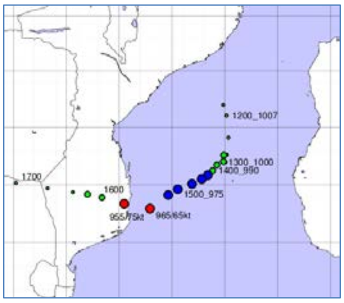


Fig. 3-28 Cyclone DINEO

- <u>Track Forecast for Cyclone Dineo</u>

Figure 3-29 shows a 72-hour forecast chart produced by INAM from JMA GSM GPV data with an initial time of 00 UTC on February 13th. The GSM predicted that the depression would develop and make landfall on southern Mozambique at around 00 UTC on the 16th of February. This was a fairly accurate three-day prediction of the depression compared to the actual track in Fig. 3-28. In the briefing, extensive discussions stemmed from comparison of several model predictions including those based on ECMWF, NOAA GFS and JMA GSM data.

- <u>Heavy rain and strong wind associated with Cyclone Dineo</u>

Figure 3-30 shows a 54-hour wind and precipitation prediction chart produced from JMA GSM GPV data with an initial time of 00 UTC on the 14th. The cyclone was considered likely to hit Inhambane Province, and heavy rainfall exceeding 50 mm/6 hours and strong winds were predicted around the cyclone after landfall. Accordingly, INAM issued the highest level of cyclone warning and called for vigilance against the expected extreme conditions.

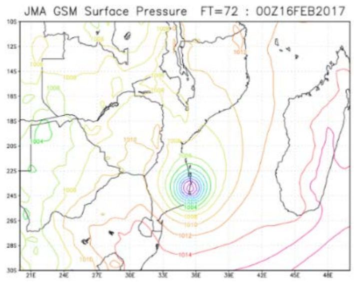


Fig. 3-29 Surface pressure
(72-hour forecast)

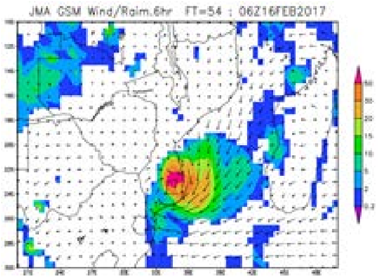


Fig. 3-30 Precipitation/Wind
(54-hour forecast)

● Observed rainfall and satellite based QPE

Figure 3-32 shows six-hour precipitation estimates derived from EUMETSAT IR data for the period from 00 to 06 UTC on the 16th of February. GSM prediction data and Hydro-Estimator values show close correspondence. As INAM has no ARG network, forecasters monitor such rainfall estimates in daily operation. Observed 24-hour rainfall from 06 UTC on the 15th to 06 UTC on the 16th is shown in Fig. 3-31. There are a number of minor stations around the cyclone track, and the maximum observed rainfall was 101.2 mm/24 hours at Vilankulo. The ARG network throughout Mozambique should be improved.

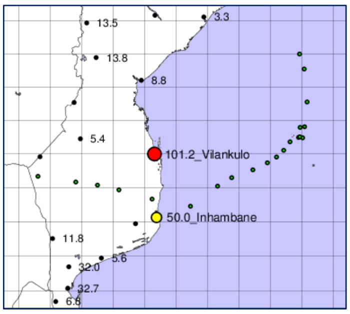


Fig. 3-31 Observed
24-hour precipitation
(15 -16 Feb 2017)

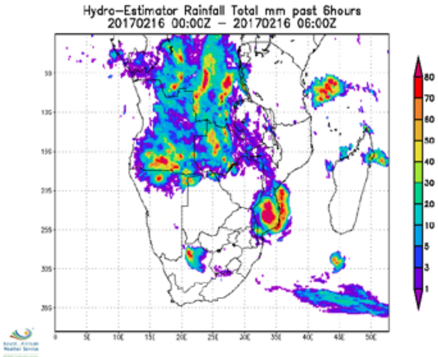


Fig. 3-32 Satellite based
6-hour precipitation
(00-06UTC 16 Feb 2017)

(b) Exercises on GPV data utilization

A forecast WG (working group) was set up in the Forecast Department, and the expert conducted exercises on GPV data utilization for WG members. The main points of the exercises covered 1) acquisition and visualization of GPV data, 2) acquisition of GPV values at stations, 3) production of temperature MOS guidance and verification, ex-post-event analysis with SATAID, and GPV data. Details of the exercises are given in Table 3-16.

Fig. 3-33 Exercise
(SATAID, GPV, MOS)

Table 3-16　Record of exercises

Date (2017)	Title and details
Jan.23	Acquisition and visualization surface GPV data ▪ Acquisition of surface JMA GSM GPV data ▪ Production of data files necessary for GPV data visualization with GrADS ▪ Production of GrADS scripts for operational forecasting
Jan.24	Acquisition of GPV values at stations ▪ Acquisition of GPV values for areas over stations ▪ Production of GPV data necessary for MOS guidance
Jan.25	Acquisition and visualization of upper GPV data ▪ Acquisition of JMA GSM upper GPV data ▪ Production of GrADS scripts for upper GPV data visualization
Jan.26	Production of temperature guidance with GPV values at stations ▪ Usage of an Excel statistical analysis tool ▪ Production of multiple regression equations for temperature at stations
Jan.29	Post-event analysis with SATAID and GPV data ▪ Usage of SATAID data for post-event analysis ▪ Usage of GPV data for post-event analysis
Jan.30	Usage of the SATAID application and SATAID data ▪ Usage of the SATAID application ▪ Storage and utilization of SATAID data for post-event analysis
Feb.2	Statistical analysis of GPV data for temperature guidance ▪ Statistical analysis of GPV data for T-max and T-min forecast guidance
Feb.13	Production of multiple regression equations and related verification ▪ Production of T-max and T-min MOS guidance ▪ Verification of MOS guidance with independent data

(c) Temperature forecast guidance

To support the utilization of weekly verification output in operational maximum and minimum temperature forecasting, the expert provided WG members with training on production of MOS forecast guidance using temperature observation data and GPV data. In consideration of INAM’s Internet accessibility situation, the WG used low-resolution GSM surface GPV data only, producing experimental forecast guidance with November and December data and verifying the results with January data. Figure 3-34 shows the verification results (RMSEs of persistency, operational forecasting and guidance). More systematic production of MOS guidance and introduction of the Kalman filter technique are planned in future activities.

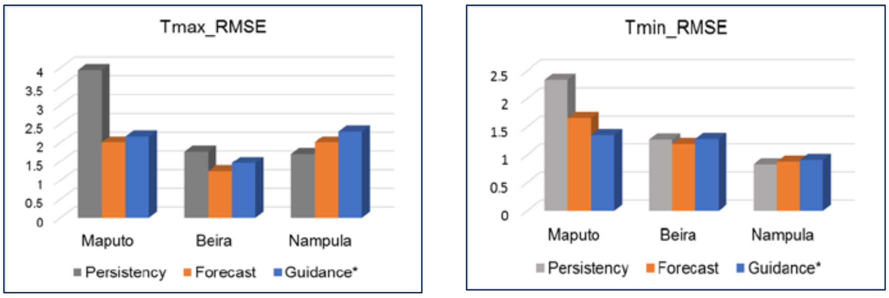


Fig. 3-34 Verification results of experimental Tmax/Tmin guidance for Maputo, Beira and Nampula

(2) Post-analysis of heavy-rain events (Satellite expert: July 2017)

The satellite expert conducted the third Activity, which included post-analysis of heavy-rain events, at INAM in July 2017. Details of the activity are provided below.

(a) Post-analysis of heavy-rain events

The expert engaged in post-analysis for five heavy-rain events that occurred during the 2016/2017 rainy season with satellite imagery and JMA GSM GPV data, and gave weather briefings to share the results with forecasters twice a day during the first week of the Activity.

● Heavy-rain event caused by a cold front (17 Jan 2017)

- Rainfall exceeding 100 mm/24 hours was observed at four stations in southern and central Mozambique in association with a remarkable cold front that passed on the 17th of January 2017 (Fig. 3-35). This was the largest-scale heavy-rain event of the 2016/2017 rainy season.
- The upper trough passed near southern Mozambique and is considered to have contributed indirectly to the formation of a remarkable cold front (Fig. 3-36, left).
- The 850-hPa temperature analysis chart for 00 UTC on the 17th of January 2017 shows prominent cold inflow to central Mozambique in association with southerly winds. Warm inflow was brought by northeasterly winds from the Mozambique Channel, and a remarkable cold front formed over southern and central Mozambique (Fig. 3-36, right).

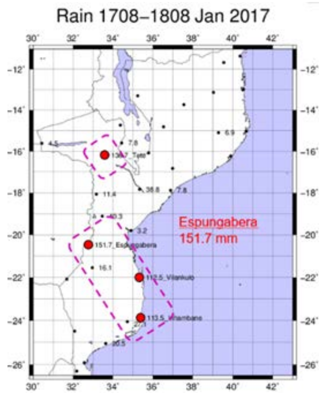


Fig. 3-35 Rainfall distribution

▪ Monitoring of surface pressure charts indicated that the high-pressure system behind the cold front intruded into Mozambique and reached the ITCZ at the peak of the event (Fig. 3-37).

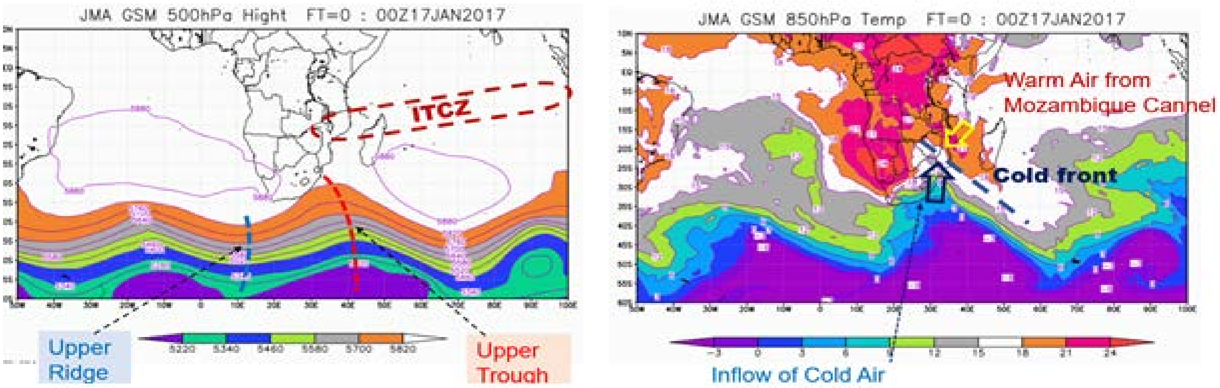


Fig. 3-36 500hPa height analysis chart (left) and 850 temperature analysis chart (right)

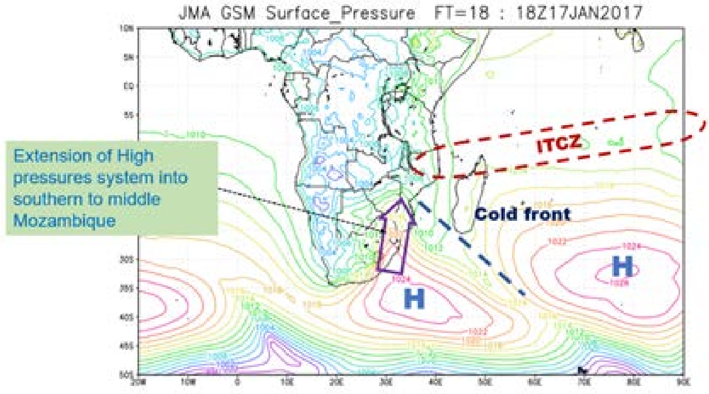


Fig. 3-37 Feature of surface analysis chart

● Heavy-rain event caused by strong convergence (26-28 Feb 2017)

▪ Rainfall exceeding 100 mm/24 hours continued from the 26th to the 28th of February 2017 around Beira in central Mozambique. This was caused by strong convergence over the area around Beira with east-southeast winds from the southern Mozambique Channel and east-northeast winds from the northern Mozambique Channel. The convergence zone remained over the same area for two days or more.

● Heavy-rain event caused by the ITCZ (6 Feb 2017)

▪ The Intertropical Convergence Zone (ITCZ) tends to be located over northern or central Mozambique in January and February, and warm southeasterly winds blowing into the zone from the Mozambique Channel often bring local heavy rainfall to the area. When there is little cold airflow from southern Mozambique into the ITCZ, heavy rainfall tends to be localized. Prediction of rainfall amounts and identification of warning areas are problematic in many cases.

● Severe storm event caused by Cyclone Dineo (15 Feb 2017)

▪ The frequency of tropical cyclone generation in the Mozambique Channel is limited, and that of tropical cyclone landfall in Mozambique is approximately once every several years to a decade.

Dineo made landfall on the southern part of the country on the 15th of February 2017 with cyclone intensity, representing the first such event in 12 years. JMA's GSM and other NWP models predicted Dineo's track fairly accurately from three days before the landfall event, and INAM issued accurate and timely cyclone warnings and information to the public (Figs. 3-29, 3-30).

(b) Temperature forecast guidance

Based on experimental results regarding the production of Tmax/Tmin forecast guidance with a multiple regression equation (MOS) during the second visit, exercises on more systematic production with MOS and Kalman filter application were conducted. Verification work was also performed with Tmax/Tmin observation data and corresponding GPV data.

● Characteristics of temperature change in Mozambique

- As it is necessary to understand the characteristics of daily and seasonal temperature change at each station in Mozambique for the production of temperature guidance, the expert analyzed temperature change based on observation data collected from December 2016 to March 2017.
- As Mozambique is long and thin from north to south, temperature changes are significant with cold fronts passing via Maputo and Xai-Xai in the south of the country, but are small in central and northern parts. Figure 3-38 shows standard deviations (SDs) of Tmax at 11 stations over the four-month period. Maputo's SD is the highest at 3.58°C and Pemba's is the lowest at 0.99°C

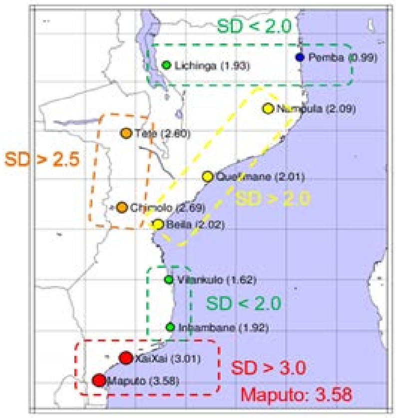
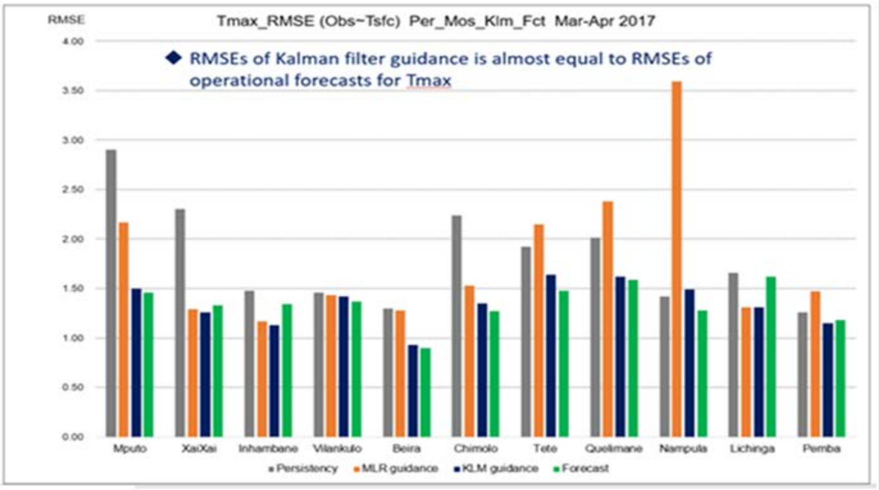


Fig. 3-38 Distribution of T-max SDs (Dec 2016 – Mar 2017)

● Production and verification of temperature guidance

- The results for temperature guidance produced with MOS during the second visit exhibited limited success except for Maputo and several stations where a relatively high correlation between GPV and Tmax/Tmin observation data was seen.
- The working group produced temperature guidance with Kalman filter and MOS application. The performance of Kalman filter guidance was compared to that of MOS guidance and operational forecasts. Figure 3-39 shows root mean square errors (RMSEs) for persistency forecasts, MOS guidance, Kalman filter guidance and operational forecasts at 11 stations for March and April 2017. As the performance of Kalman filter guidance was superior to that of MOS guidance and similar to that of operational forecasts, the working group decided to use Kalman filter guidance for future operational forecasting.



◆ RMSEs of Kalman filter guidance is almost equal to RMSEs of operational forecasts for Tmax

Fig 3-39 Verification of Tmax forecast guidance. RMSEs of persistency forecast (gray), MOS guidance (orange), Kalman filter guidance (blue) and operational forecasts (green).

(3) Forecast OJT during the 2017/18 rainy season (Satellite expert: January to March 2018)

The satellite expert conducted the second round of OJT for INAM forecasters in the forecasting operation room during the 2017/2018 rainy season as detailed below.

(a) Exercises and presentations on weather guidance and temperature guidance

A four-member working group consisting of Alberto Queiroz, Guelso Manjate, Manuel Francisco and Hipólito Cardoso was set up for OJT in the Forecast Department. This membership was similar to that for the second visit to INAM.

During the second week of the fourth visit, exercises and presentations highlighting weather and temperature guidance for the improvement of daily forecasting products at INAM covered 1) a review of SATAID and JMA GSM GPV data usage, 2) an outline of weather guidance and related operational usage, 3) usage of weather guidance in daily forecasting, 4) an outline of Tmax/Tmin guidance and related operational usage, and 6) usage of Tmax/Tmin guidance in daily forecasting (Table 3-17). Focus was placed on the usage of guidance in daily weather forecasting rather than on guidance programs.

Fig. 3-40 Exercise on guidance

Table 3-17 Record of exercises and presentations

Date (2018)	Title and details
Feb. 5th	▪ Procedures for issuance of forecasts and warnings ▪ Utilization of SATAID and JMA GSM GPV data
Feb. 6th	▪ Acquisition of GPV values necessary for the production of weather guidance ▪ Outline of weather guidance production
Feb. 7th	▪ Outline of calculation to determine POP, average cloud amounts and maximum wind ▪ Usage of weather guidance for next-day forecasts
Feb. 8th	▪ Production of Tmax/Tmin guidance using the Kalman filter technique ▪ Updating of coefficients for regression equations using observation data
Feb. 9th	▪ Usage of SATAID data for post-event analysis ▪ Usage of GPV data for post-event analysis

(b) Forecast briefing

Following the exercises and presentations conducted in the second week, the working group started forecast briefing on the 13th of February not only for daily weather forecasting but also for sharing of related activities with forecasters. All working group members played prominent roles in the briefing (Fig. 3-41), providing forecasters and related staff with information on predictions of JMA's GSM and WRF models including the results of weather guidance and Tmax/Tmin guidance. The forecast briefing was generally conducted in line with the procedure detailed in Fig. 3-42.

Forecast briefing is a daily scheduled task of duty forecasters, but the current circumstances of INAM's Forecast Department make daily implementation impractical. Against this background, briefing should be provided in the event of extreme weather conditions based on instructions from the chief forecaster or director of the Forecast department.

Fig. 3-41 Forecast briefing by working group members

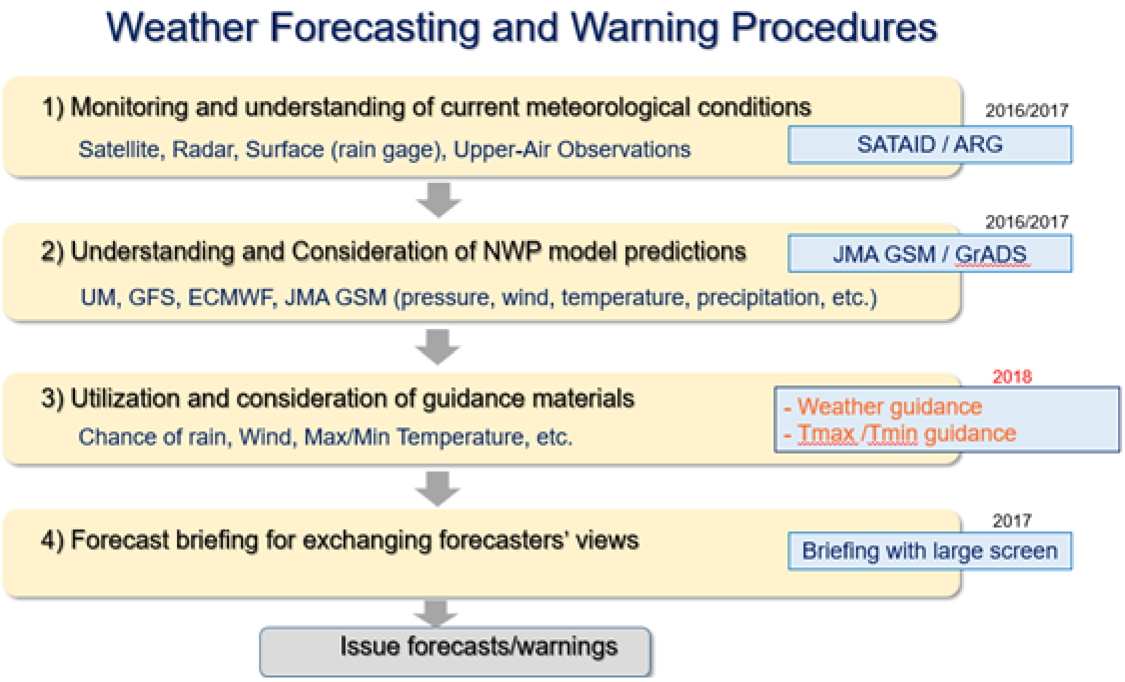


Fig. 3-42 Diagram of forecasting procedures and contents of technical transfer through the forecast OJT

(c) Technical visit to SAWS

The South African Weather Service (SAWS) has been designated as a center for WMO's Severe Weather Forecast Demonstration Project (SWFDP) since 2006, and provides a variety of SWFDP products for southern African countries including Mozambique. INAM uses information such as potential heavy-rain area data and distribution charts of satellite-based precipitation estimation at all times in its weather forecasting.

The expert visited SAWS with IMAM Deputy General Director Mussa Mustafa on the 27th of February 2018 to learn about SWFDP activities for further improvement of weather forecasting and warnings at INAM. The visit proved quite fruitful in terms of gathering information on daily forecasting procedures, SWFDP guidance products and training activities in SAWS. It was also a good opportunity for INAM to strengthen mutually supportive relations with SAWS staff.

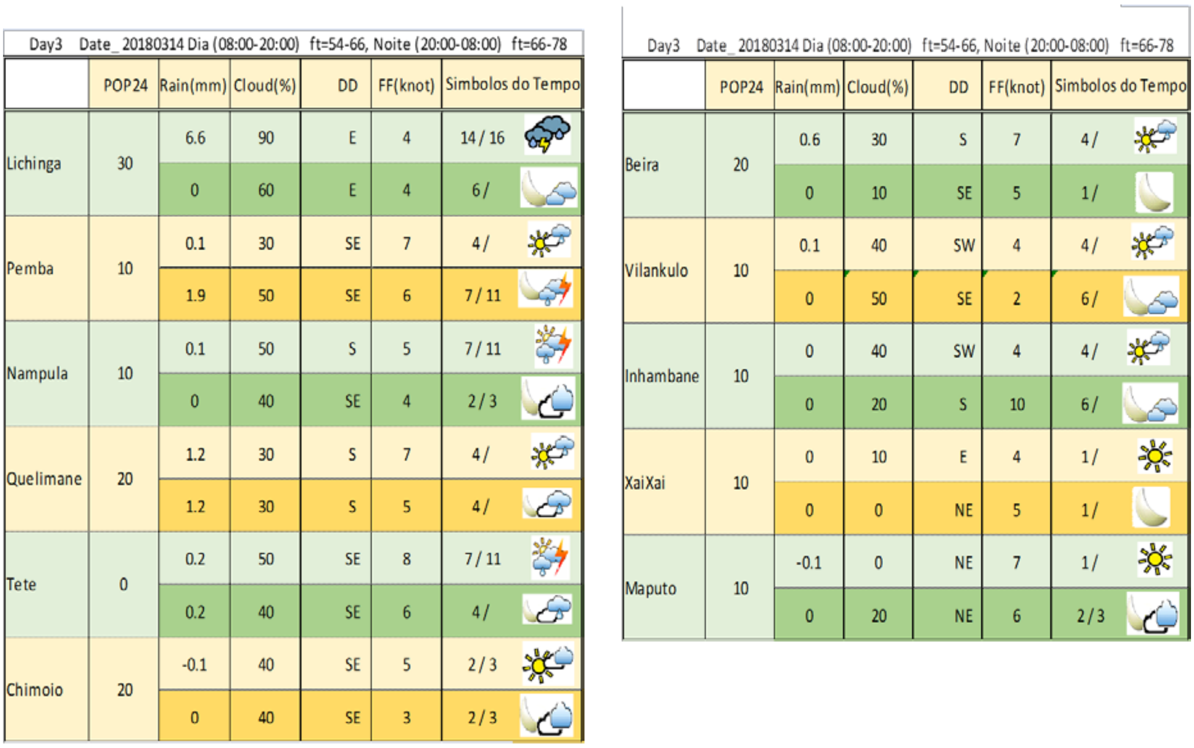
(d) Finishing exercises

During the sixth and seventh weeks of the fourth visit, the following finishing exercises were conducted to update and maintain guidance programs for continuous related application: 1) composition of weather and Tmax/Tmin guidance programs, 2) updating of the monthly GPV observation data set, 3) verification of Tmax/Tmin guidance for January and February 2018, 4) investigation of possible predictors for the improvement of Tmax/Tmin guidance, 5) objective determination of codes/symbols for weather guidance, and 6) updating of precipitation data for POP guidance (Table 3-18). The exercises helped the working group to understand the benefits of weather guidance and Tmax/Tmin guidance in daily forecasting services. The guidance programs were also improved based on the experimental use of weather guidance and Tmax/Tmin guidance.

Samples of weather guidance, Tmax/Tmin guidance and related verification are shown in Figs. 3-43, 3-44, 3-45, 3-46 and 3-47.

Table 3-18 Record of finishing exercises

Date (2018)	Title and details
Mar. 05, 06	▪ Composition of the weather and Tmax/Tmin guidance programs ▪ Updating of monthly GPV and observation data
Mar. 07, 08	▪ Monitoring of daily Tmax/Tmin guidance performance ▪ Statistical verification of temperature guidance for January and February 2018
Mar. 09,	▪ Investigation of possible predictors for improvement of the Tmin/Tmax guidance
Mar. 12, 13	▪ Improvement of Tmax/Tmin guidance with multiple predictors ▪ Updating of regression equation coefficients with observation data
Mar. 14, 15	▪ Objective determination of codes/symbols for weather guidance ▪ Usage of Tmax/Tmin guidance for next-day forecasts
Mar. 20, 21	▪ Updating of monthly precipitation data for POP guidance ▪ Maintenance of weather guidance and Tmax/Tmin guidance



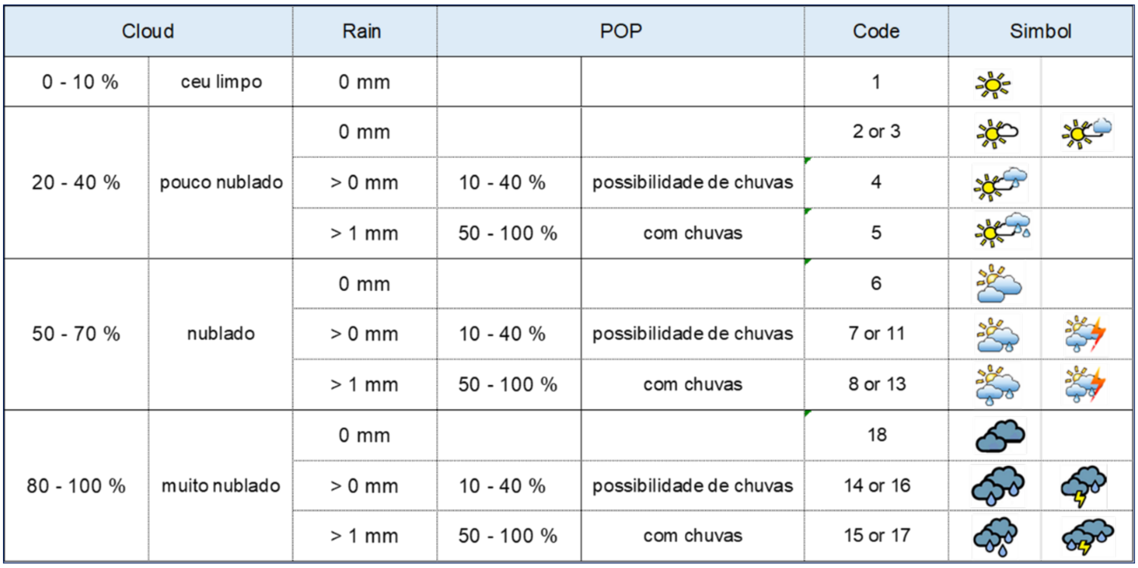
Day3 Date_ 20180314 Dia (08:00-20:00) ft=54-66, Noite (20:00-08:00) ft=66-78

	POP24	Rain(mm)	Cloud(%)	DD	FF(knot)	Simbolos do Tempo
Lichinga	30	6.6	90	E	4	14 / 16
		0	60	E	4	6 /
Pemba	10	0.1	30	SE	7	4 /
		1.9	50	SE	6	7 / 11
Nampula	10	0.1	50	S	5	7 / 11
		0	40	SE	4	2 / 3
Quelimane	20	1.2	30	S	7	4 /
		1.2	30	S	5	4 /
Tete	0	0.2	50	SE	8	7 / 11
		0.2	40	SE	6	4 /
Chimoio	20	-0.1	40	SE	5	2 / 3
		0	40	SE	3	2 / 3

Day3 Date_ 20180314 Dia (08:00-20:00) ft=54-66, Noite (20:00-08:00) ft=66-78

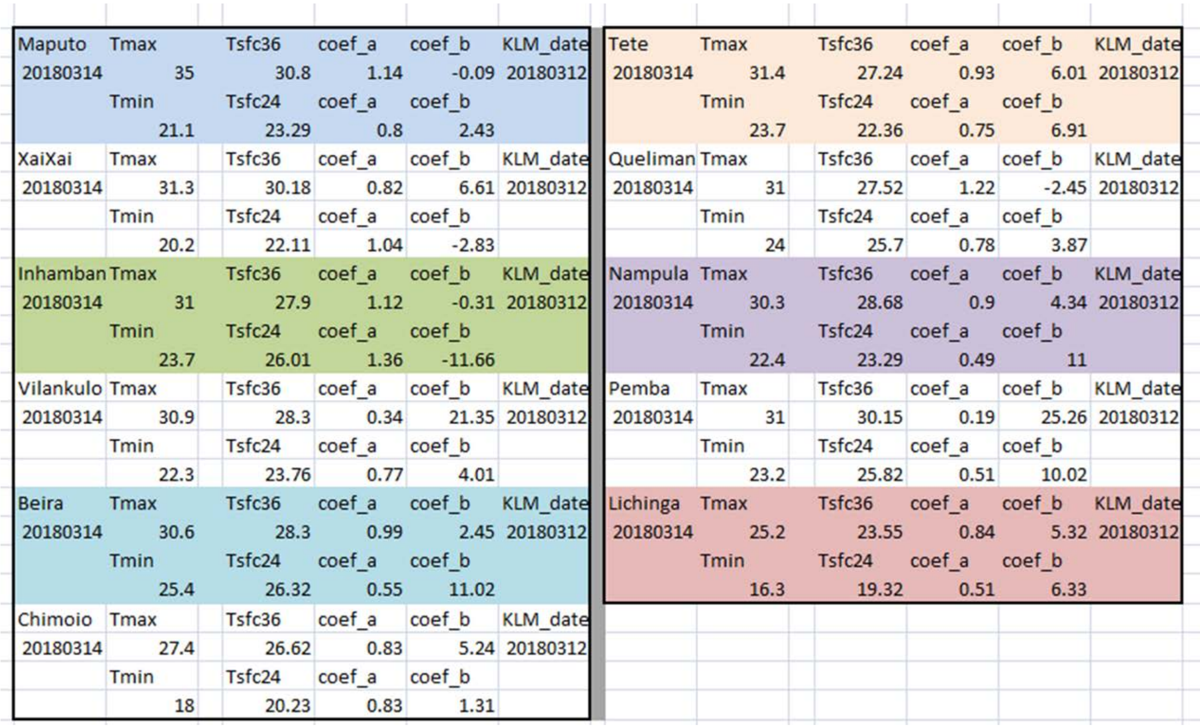
	POP24	Rain(mm)	Cloud(%)	DD	FF(knot)	Simbolos do Tempo
Beira	20	0.6	30	S	7	4 /
		0	10	SE	5	1 /
Vilankulo	10	0.1	40	SW	4	4 /
		0	50	SE	2	6 /
Inhambane	10	0	40	SW	4	4 /
		0	20	S	10	6 /
XaiXai	10	0	10	E	4	1 /
		0	0	NE	5	1 /
Maputo	10	-0.1	0	NE	7	1 /
		0	20	NE	6	2 / 3

Fig. 3-43 A sample of weather guidance. Weather guidance is prepared for 11 major cities every 12 hours up to 84 hours ahead.



Cloud		Rain	POP		Code	Simbol	
0 - 10 %	ceu limpo	0 mm			1		
20 - 40 %	pouco nublado	0 mm			2 or 3		
		> 0 mm	10 - 40 %	possibilidade de chuvas	4		
		> 1 mm	50 - 100 %	com chuvas	5		
50 - 70 %	nublado	0 mm			6		
		> 0 mm	10 - 40 %	possibilidade de chuvas	7 or 11		
		> 1 mm	50 - 100 %	com chuvas	8 or 13		
80 - 100 %	muito nublado	0 mm			18		
		> 0 mm	10 - 40 %	possibilidade de chuvas	14 or 16		
		> 1 mm	50 - 100 %	com chuvas	15 or 17		

Fig. 3-44 Algorithm to determine whether Code objectively in weather guidance



Maputo	Tmax	Tsfc36	coef_a	coef_b	KLM_date	Tete	Tmax	Tsfc36	coef_a	coef_b	KLM_date
20180314	35	30.8	1.14	-0.09	20180312	20180314	31.4	27.24	0.93	6.01	20180312
	Tmin	Tsfc24	coef_a	coef_b			Tmin	Tsfc24	coef_a	coef_b	
	21.1	23.29	0.8	2.43			23.7	22.36	0.75	6.91	
XaiXai	Tmax	Tsfc36	coef_a	coef_b	KLM_date	Queliman	Tmax	Tsfc36	coef_a	coef_b	KLM_date
20180314	31.3	30.18	0.82	6.61	20180312	20180314	31	27.52	1.22	-2.45	20180312
	Tmin	Tsfc24	coef_a	coef_b			Tmin	Tsfc24	coef_a	coef_b	
	20.2	22.11	1.04	-2.83			24	25.7	0.78	3.87	
Inhamban	Tmax	Tsfc36	coef_a	coef_b	KLM_date	Nampula	Tmax	Tsfc36	coef_a	coef_b	KLM_date
20180314	31	27.9	1.12	-0.31	20180312	20180314	30.3	28.68	0.9	4.34	20180312
	Tmin	Tsfc24	coef_a	coef_b			Tmin	Tsfc24	coef_a	coef_b	
	23.7	26.01	1.36	-11.66			22.4	23.29	0.49	11	
Vilankulo	Tmax	Tsfc36	coef_a	coef_b	KLM_date	Pemba	Tmax	Tsfc36	coef_a	coef_b	KLM_date
20180314	30.9	28.3	0.34	21.35	20180312	20180314	31	30.15	0.19	25.26	20180312
	Tmin	Tsfc24	coef_a	coef_b			Tmin	Tsfc24	coef_a	coef_b	
	22.3	23.76	0.77	4.01			23.2	25.82	0.51	10.02	
Beira	Tmax	Tsfc36	coef_a	coef_b	KLM_date	Lichinga	Tmax	Tsfc36	coef_a	coef_b	KLM_date
20180314	30.6	28.3	0.99	2.45	20180312	20180314	25.2	23.55	0.84	5.32	20180312
	Tmin	Tsfc24	coef_a	coef_b			Tmin	Tsfc24	coef_a	coef_b	
	25.4	26.32	0.55	11.02			16.3	19.32	0.51	6.33	
Chimoio	Tmax	Tsfc36	coef_a	coef_b	KLM_date						
20180314	27.4	26.62	0.83	5.24	20180312						
	Tmin	Tsfc24	coef_a	coef_b							
	18	20.23	0.83	1.31							

Fig. 3-45 A sample of Tmax/Tmin guidance. Tmax/Tmin guidance is prepared for 11 major cities for tomorrow.

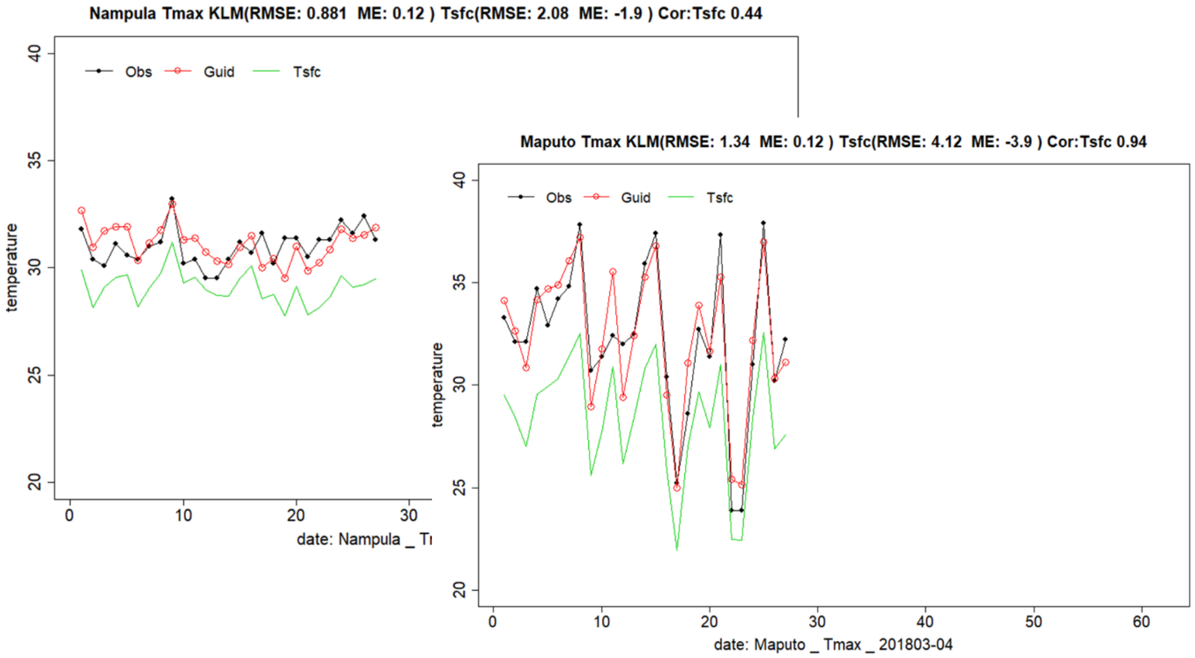
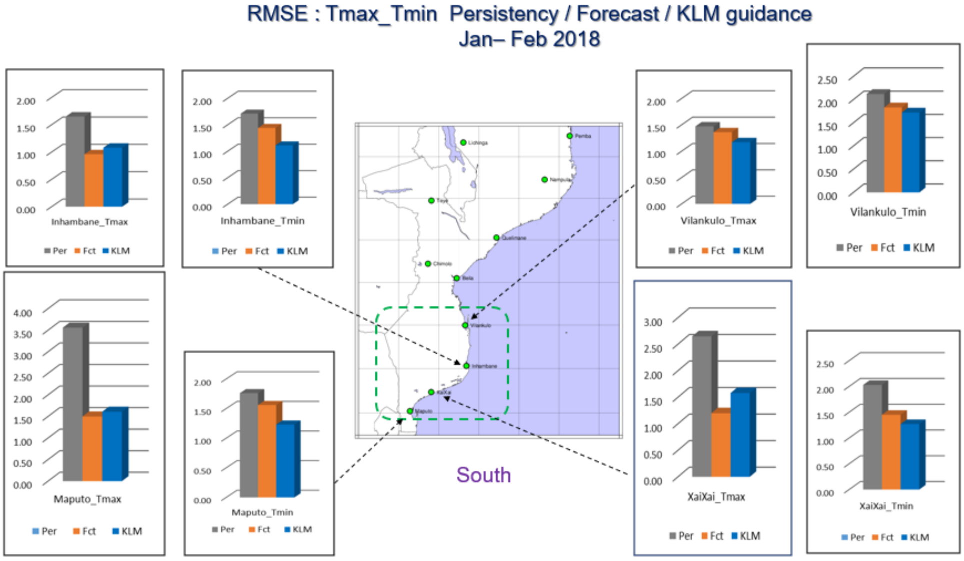
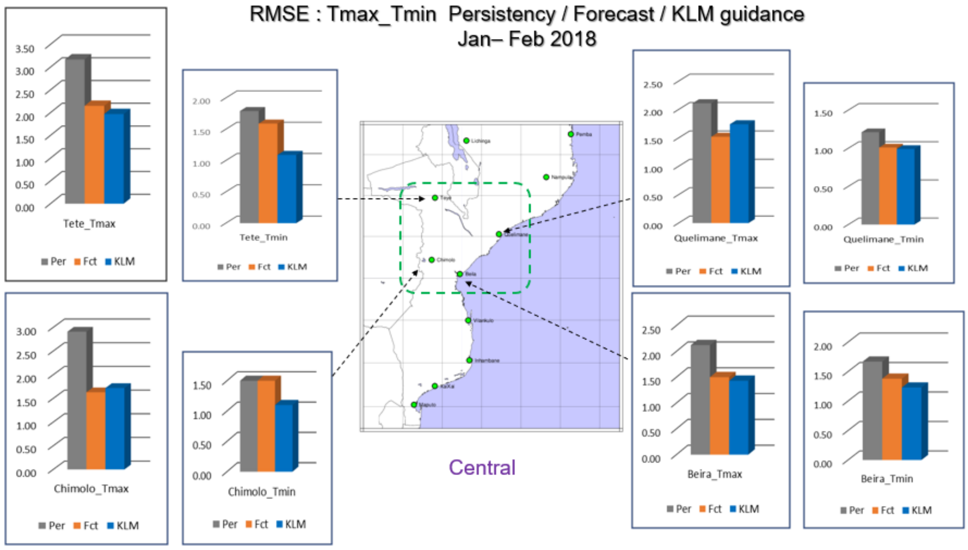


Fig. 3-46 A sample of monitoring chart for Tmax/Tmin guidance. Guidance (red), Observation (black) and GPV (green).


RMSE : Tmax_Tmin Persistency / Forecast / KLM guidance
Jan– Feb 2018


RMSE : Tmax_Tmin Persistency / Forecast / KLM guidance
Jan– Feb 2018

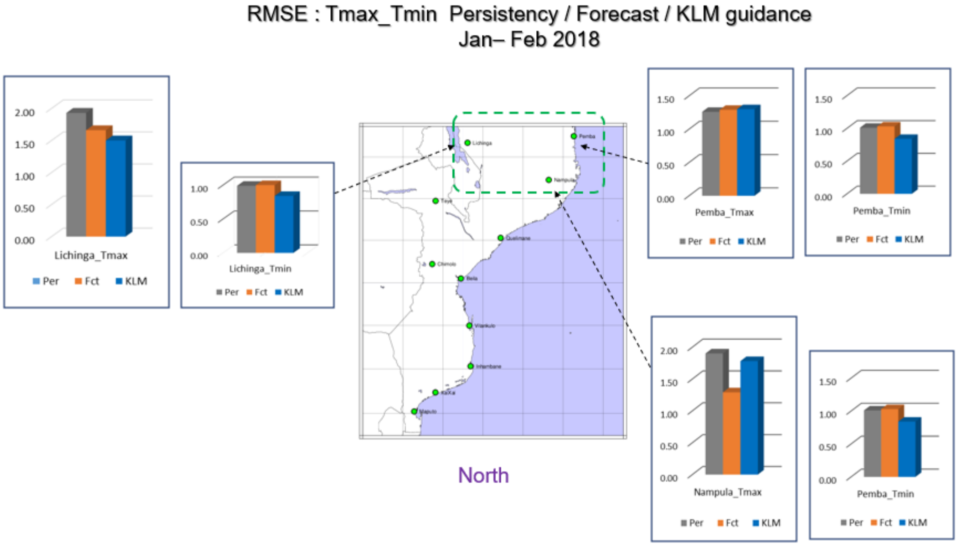

RMSE : Tmax_Tmin Persistency / Forecast / KLM guidance
Jan– Feb 2018

Fig. 3-47 Verification results of Tmax/Tmin guidance for Jan-Feb 2018. RMSEs of Persistency forecast (gray), Operational forecast (orange) and Guidance (blue).

(4) Outcome of technical expertise transfer

- Environmental arrangements for the utilization of JMA GSM GPV data and related downloads
- GrADS scripts for visualization of JMA GSM GPV data
- Weather guidance program and training materials on weather guidance usage
- Temperature guidance program and training materials on temperature guidance usage
- Training materials on verification of temperature guidance and updating of monthly data
- Training materials on production of presentation documents for weather briefing

3. 5. 5 Issues and devices for further activities

(1) Remarks on activities

From the baseline survey, the expert team discovered system failures on GTS, EUMETSAT and SADIS, and found that INAM was unable to use GPV and satellite digital data operationally. The enhancement of weather forecasting capacity requires training on meteorology and forecasting expertise via presentations. OJT based on daily operations (i.e., weather forecasting) also provides valuable opportunities for the sharing of meteorological know-how, thereby allowing numerous forecasters to develop their expertise. In this context, data accumulation is essential for OJT on weather forecasting, historical data storage, evaluation of past forecasts and discussion of previous events.

On the other hand, INAM stores daily forecasts, observation report for clients on PCs and records on books. So the forecast team and the expert tried to type in and store them for their OJT.

To this end, the team procured a PC in Mozambique and began data accumulation for meteorological materials that INAM has commonly used since October 2015. Using this stored data, the team embarked on event evaluation and verification activities. In this way, information supporting meteorological expertise can be stored/shared and weather forecasting capacity can be improved through continuous review.

A user ID and password are needed to access the secure SAWS server data storage facility. The team and INAM obtain this information from SAWS to enable data access.

The introduction of AWS and SATAID has allowed preparations for real-time monitoring of heavy rainfall. Forecasting OJT provided over two rainy seasons by the satellite expert has also helped to improve weather forecasting and related technical transfer at INAM. Despite communication network-related issues with meteorological data availability at INAM, effective technical transfer has been achieved with relatively modest investment as a result of work to promote data storage, introduction of AWS, forecast verification, provision of ongoing forecasting OJT and other measures.

(2) Working group organization

A forecast working group consisting of several members (Table 3-19) convenes as necessary to support the conduct of effective exercises and presentations. The expert team also worked to share the main content of exercises and presentations with forecasters outside the group via technical meetings and forecasting OJT.

Table 3-19　Working group member (weather forecast)

Member	Department
Queiroz Alberto	Weather Forecast Department
Hipolito Cardoso	
Manuel Francisco	
Guelso Manjate	
Jonas Zucula	Climate Division

3. 5. 6　Project wrap-up seminar and meeting

(1) Project open seminar

The INAM/JICA Seminar on Natural-disaster Preparedness and National Resilience held on the 19th of March 2018 was attended by 35 people, many of whom were from external organizations and media outlets. Figure 3-48 shows a group photo of the attendees, a JICA representative in a TV/print-media interview and a scene from the seminar, which was widely reported in Mozambique.

The presentation titles were: Preparedness for and Resilience to Natural Disasters in Mozambique (INGC); Media Roles in Natural-disaster Risk Mitigation (newspaper publisher); Mozambique’s Early Warning System (INAM forecasting representatives); INAM Strategy Supporting Preparedness for and Resilience to Natural Disasters (INAM director-general); and JICA Project Activities and Achievements (JMBSC expert). Fruitful discussions on disaster preparedness and the early warning system in Mozambique extended significantly beyond the scheduled time, and INAM received valuable feedback on its warnings and early warning system from external attendees. INAM should make efforts to deepen exchanges with disaster-related organizations and media for optimal development of related opportunities.

Fig. 3-48　Participants of the Seminar, Interview by TVs and Appearance of the Seminar

Seminário sobre a Preparação e Resiliência Nacional aos Desastres Naturais, Maputo, Hotel Cardoso, 19 de Março de 2018

Programa do Seminário

HORA	TÓPICO	Moderador
09.00 – 09.15	Registo dos participantes	
09.15 – 09.30	**Sessão de Abertura** • **Representante da JICA – Hiroaki ENDO** • **Director-Geral do INAM – Adérito Aramuge**	**Mussa Mustafa (Director-Geral Adjunto -INAM)**
09.30 – 10.00	Sessão de Fotografia e Café da Manhã	
10.00 – 10.15	Estrategias para a Redução do Risco de desastres Naturais em Moçambique	**INGC**
10.15 – 10.30	Fortalecimento do Sistema de Aviso Prévio	**INAM**
	• **Desafios do INAM na Reducao do Risco de Desastres Naturais** • **Previsões Baseadas no Imapcto**	**Queiroz Alberto** **Jose Sawanguana**
10.30 – 10.45	Papel dos Mídia na Redução de Riscos de Desastres Naturais	**Osvaldo Gemo**
10.45 – 11.00	Contribuição do JMBSC no Sistema de Aviso Prévio	**Michihiko Tonouchi -JMBSC**
11.00 – 11.15	Estratégia do INAM na Preparação e Resiliência no respeitante aos Desastres Naturais	**Adérito Aramuge**
11.15 – 11.45	Debate	**Participantes**
11.45 – 11.55	Considerações Finais e Encerramento	**JICA/INAM**
12.00 – 13.00	Almoço	**Participantes**

Fig. 3-49 Program of the Seminar

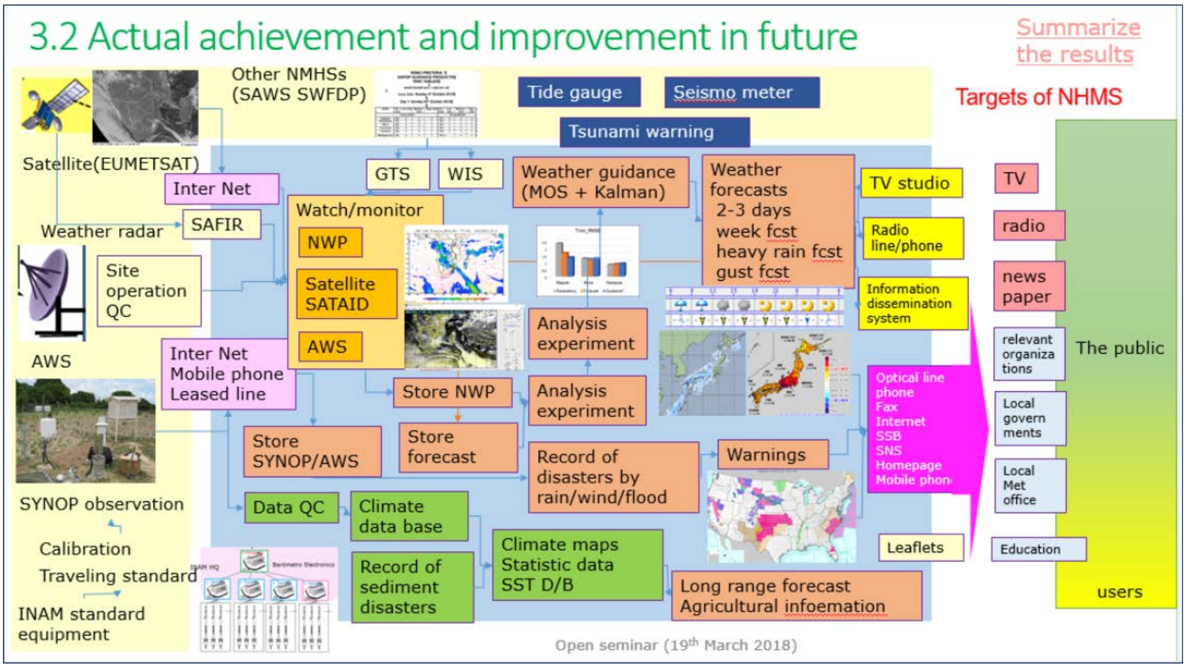
(2) Meeting with INAM staff

INAM and the JICA expert team held a wrap-up meeting on the 22nd of March 2018 to review activities and achievements in individual fields for the three-year project launched in May 2015. Around 30 people from INAM, including the DG, the vice-DG and the directors of relevant departments, attended.

The DG thanked JICA and the expert team for their work on the implementation of the project and expressed expectations for future project activities. A representative from the Observation Department requested assistance with the AWS network and maintenance of traceability. Another representative from the Forecast Department reported that forecast guidance had been highly effective in operational forecasting and expressed hopes for a greater number of target stations in the near future.

Fig. 3-50 finishing Meeting

The expert team raised questions about the future direction of improvements to its services via an overview diagram highlighting the current status of INAM meteorological services. Most INAM staff appeared to have previously had only limited opportunities to discuss future improvement strategy, and there was little scope for active discussions in this area at the meeting. The expert team views this kind of gathering as a potential stepping stone toward systematic improvement of INAM's meteorological services with positive leadership from the DG and the vice-DG toward practical implementation of improvement plans.



3.2 Actual achievement and improvement in future

Summarize the results

Targets of NHMS

Other NMHSs (SAWS SWFDP)

Tide gauge

Seismo meter

Tsunami warning

Satellite(EUMETSAT)

Inter Net

Weather radar

SAFIR

Site operation QC

AWS

Inter Net
Mobile phone
Leased line

SYNOP observation

Calibration

Traveling standard

INAM standard equipment

GTS

WIS

Watch/monitor

NWP

Satellite SATAID

AWS

Store NWP

Store SYNOP/AWS

Store forecast

Data QC

Climate data base

Record of sediment disasters

Climate maps
Statistic data
SST D/B

Weather guidance (MOS + Kalman)

Analysis experiment

Analysis experiment

Record of disasters by rain/wind/flood

Weather forecasts
2-3 days
week fcst
heavy rain fcst
gust fcst

Warnings

Long range forecast
Agricultural infoemation

TV studio

Radio line/phone

Information dissemination system

Optical line
phone
Fax
Internet
SSB
SNS
Homepage
Mobile phone

Leaflets

TV

radio

news paper

relevant organizations

Local governments

Local Met office

Education

The public

users

Open seminar (19th March 2018)

Fig. 3-51 An overview diagram of the current status of INAM's meteorological services

3. 6 JICA expert activities

3. 6. 1 Activity Plan

(1) Output and Verifiable Indicators

[Output]

Capacities in weather forecasting and warnings are enhanced.

[Indicator]

2-1. At least 3 staff of INAM obtains ability to use ground observation, ARG, satellite and GPV data for forecasting.

2-2. At least 3 staff, in charge for operational forecast, of INAM obtains ability to operate comprehensive weather forecasting.

(2) Activity Plan

[Activities]

2-1. Conduct baseline survey and identify issues about weather forecasting and warning

2-2. Conduct trainings of Weather forecasting Method

2-3. Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, meteorological radar, and Satellite & GPV data

2-4. Conduct follow-up activities to establish comprehensive weather forecast & warning by using the output of activity 2-2 & 2-3

2-5. Conduct baseline survey to identify needs of each users such as INGC4, DNA, Media & private company and identify issues on weather forecast and warning provided by INAM

2-6. Improve weather forecast and warning based on the findings of activity 2-5

3. 6. 2 Project activities

(1) Implementation of follow-up activities to establish quality control for meteorological radar data and checking of meteorological radar

Original plan

To determine comprehension of the guidelines on weather radar checking and data quality control implemented under the project, survey check sheets will be created by the relevant JICA expert. Based on the results of the survey, other radar experts on the project will carry out training to enhance the performance of INAM staff handing meteorological operations. In the event of radar malfunction, the JICA expert will encourage INAM to implement early resolution

The radar experts on the project team (Masaru Wakabayashi and Masahiro Nagashima) conducted detailed investigations of the current conditions of the Beira and Xai-Xai radars on their first and second visits, and presented the recovery policy in another report.
The main points were as follows:

- Provision of a stable supply of commercial electric power to the observatory is a minimum requirement for the recovery of Beira radar functionality. If radar control parts, signal-processing parts and picture monitoring instruments can also be replaced, stable operation of Beira radar is considered possible.

- Xai-Xai radar was improved by the underground connection of a new cable from a newly installed electric pole to the radar observatory. However, the power supply has been stopped because significant resistance was lost by the removal of equipment for power receipt and switching. Some important parts of the radar also malfunctioned, and the observatory building is run down. Accordingly, it would not be efficient to invest significantly in restoring Xai-Xai radar operation.

- If no clear prospect of recovery for Beira radar operation can be expected, the initially planned provision of training for radar maintenance and utilization of radar observation data appears impractical. INAM’s clear input on this matter is required.

- The JICA project team advised INAM that a stable supply of commercial power to the Beira radar site was a minimum precondition for the provision of training on radar maintenance, and requested that the issue be addressed. Issues with power supply stability continued until the team’s third visit, rendering training on radar maintenance impractical during this phase.

- The JICA project team advised INAM to consider forecast training on the use of meteorological satellite (EUMETSAT) data rather than meteorological radar data. This point was reinforced at the JCC Meeting in September 2016.

(2) Follow-up activities to establish the traceability and inspection of meteorological instruments

The original plan
To determine comprehension of the guidelines on traceability and inspection of meteorological instruments under the project, survey check sheets will be created by the relevant JICA expert. Based on the results of the survey, other experts on the project will carry out training to enhance the performance of INAM staff handling meteorological instrument maintenance. If staff coverage is considered insufficient, the JICA expert will ask INAM to provide more personnel. If the number of supervisors is considered insufficient, JMBSC will ask INAM to reinforce its management in this regard.

The surface observation experts on this project team (Koji Matsubara and Chuji Yamamoto) reported on their activities as detailed in Chapter 3.1: Traceability of meteorological instruments and Chapter 3.2: Surface observation.

The main points covered up until the third visit are as follows:

- As two INAM standard digital barometers were certified based on INNOQ inspection in 2014, the results of inter-comparison with the team's standard barometer can be considered highly favorable.

- The inspection situation at local observation stations other than Maputo Airport remains unknown, as no clear records were present and instruments did not bear certification stickers. One of the team's future tasks is to consider and transfer instrument inspection technology at local observation stations.

- Inspection equipment and standard instruments at INAM are not verified and remain unusable due to breakdown or malfunction. Accordingly, the facility is not suitable for inspection or instrument storage. Standard instruments should be kept in cabinets or designated cases. JMA's Hiroshi Kawamura JMA also noted this during an inspection visit.

- Koji Matsubara provided nine INAM staff with OJT on barometer/thermometer calibration using new digital barometers/thermometers donated to INAM by JICA, and created Portuguese-language manuals for this new equipment. INAM staff members should practice calibration using these instruments until Mr. Matsubara's next visit.

- Calibration of the new barometers and thermometers used for this training was conducted by RIC Tsukuba/JMA in response to a request from the director-general of INAM.

- Activity plans for the next phase are currently being formulated within the team. Considerations include methods of inspection for new barometers and thermometers at local observatories (i.e., surface observation stations), formulation of appropriate correction tables based on the results of instrument inspection, and usage of field observation notebooks.

Activities of the 4th visit

Monitoring survey based on a self-diagnosis check sheet regarding technical capacity for calibration and meteorological instrument maintenance

- Training on traceability establishment and calibration techniques for meteorological surface observation instruments were carried out by project team members Koji Matsubara and Chuji Yamamoto. JMA experts also conducted training at RIC/Tsukuba in Japan and at INAM in Maputo.

Kota Nakai conducted a monitoring survey to evaluate the results of the training using a self-diagnosis check sheet. The eight people who attended the training given by the experts dispatched from JMA in September 2016 were selected as survey respondents, having received training attendance certificates.

- The self-diagnosis check sheet questions and responses are shown in Appendix H-1. The responses are summarized below。

① Traceability Establishment

All eight trainees appear to have understood the content well. However, focus should be placed on further understanding of roles to be performed at INAM.

② Barometer calibration

The trainees appear to have understood the measurement principle of standard (digital) barometers as well as the working principle of pressure adjusters for related calibration, and were able to conduct suitable operation. However, understanding was lacking in relation to the necessity for correction of mercury barometer instrument errors and correction values for temperature and gravity. Knowledge of how to calculate individual correction values was also limited, rendering such calculation impractical. During this work, Chuji Yamamoto of the team gave presentations on correction methodology in the class of domestic group training for local observatory staff. In future work, re-training on correction methodology should be provided to personnel handling instruments at INAM HQ.

③ Thermometer calibration

The trainees understood the measurement principle of standard platinum resistance thermometers and the working principle of liquid bath chambers, and were able to conduct appropriate operation.

④ Maintenance of Barometers and Thermometers at Local Observatories

In this category, responses indicating a lack of related expertise were given for each item.

Kota Nakai plans training content to address this issue.

Activities of the 5th visit

Technical guidance on surface meteorological observation

- Practical training on digital thermometer calibration

JICA supplied INAM with three sets of digital thermometers and digital hygrometers in January 2017. Kota Nakai provided practical training for calibration of two sets of digital thermometers to five INAM staff handling instrument maintenance along with the team's Kiichi Sasaki from the 16th to the 19th of January. It took a long time to set the freezing point using shaved ice at the beginning of the training and some staff were initially unfamiliar with appropriate handling of the liquid chamber used for calibration, but the attentive teaching provided by the trainers produced positive result.

- The team's Koji Matsubara provided the same instrument maintenance staff with training on calibration of the third thermometer on the 13th and 14th of February, resulting in the capacity to output validated, error-free results. Despite the repeated provision of this kind of training, there were large errors at the beginning of the session due to factors such as the length of time since the last training session and the fact that the sensor of the thermometer brought for calibration was shorter than the standard. However, appropriate training was provided with instruction from Koji Matsubara.

- Checking and updating of metadata required for creating mercury barometer correction tables
  Little progress was observed with the INAM Synop observatory metadata checking/updating that had been strongly advised by Chuji Yamamoto and Kota Nakai during the fourth visit. As such work is indispensable in the production of correction tables for accurate observation using mercury barometers, a need was identified for clearer demonstration of methods for updating and completion to create accurate correction tables for each observatory during the sixth visit.

(3) Training on weather forecasting methods

Original plan
JICA expert (Kota Nakai) will carry out the following training/ lectures, in advance of training on weather forecasting and warning by using surface meteorological observation, meteorological radar, Satellite and GPV data and

- Importance of weather forecasting
- Roles of weather forecasters
- Characteristics and causes of extreme weather phenomena (lows, cyclones, tornadoes, heavy rain, strong winds)
- Introduction of NWP

At the time of the end of lectures, achievement evaluation will be performed to utilize the results for next training.

During his second visit, JICA expert and project team leader Kota Nakai conducted presentations on the areas listed below for INAM forecasters to highlight the importance of weather forecasting services and promote a strong sense of responsibility in related work.

- Roles of national meteorological services
- JMA weather forecasting services
- Important areas of weather forecasting work
- Introduction to numerical weather prediction

Two identical presentations were given over periods of three days each to a total of around ten highly motivated staff. Responses to a post-presentation questionnaire identified the level of the *Introduction to numerical weather prediction* presentation variously as difficult, suitable and easy.

Kota Nakai's presentation content during the third visit included numerous examples highlighting the system for JMA's weather warning formulation/dissemination and the system for flood forecasts and warnings in Japan toward improvement of current INAM weather warnings. Attended by 14 people, the presentation addressed JMA's real-time utilization of data from around 50 weather radars and around 5,000 ground-based rain gauges operated by domestic organizations to support the issuance of flood warnings and evacuation alerts. The training highlighted that it had taken decades of development for Japan to reach its current situation. Against this background, it is considered important and highly effective to collaborate with other organizations and engage in mutual sharing of rainfall data. Hopes are high that this model will also be considered in Mozambique.

Activities of the 4th visit

Training on weather forecasting

- Toward further improvement of weather forecast technology, Kota Nakai planned seminar-based training on fundamental weather systems using an English-language textbook titled Atmospheric Science: An Introductory Survey with a proposal that INAM forecasters take turns as presenters. However, due to the time taken to prepare for presentations and the duty-related commitments of forecasters, Mr. Nakai gave all presentations except in the third seminar.
- The forecasters initially struggled to understand the textbook's coverage of Northern Hemisphere low-pressure areas in relation to extratropical cyclones. Mr. Nakai took time to clarify the details and spent hours on questions and answers in this area. He also covered various phenomena associated with deep convection.
- At the end of each seminar, the trainees reported a general understanding of the matters covered.

(4) Follow-up activities to establish comprehensive weather forecasting and warnings

Original plan

The JICA expert will collect weather information (forecasts, advisories and warnings) issued by INAM in collaboration with INAM staff when extreme weather phenomena occur in Mozambique. Announcement timing and information target areas will be validated in collaboration with INAM staff, and the results will be incorporated in future manual content.

- In 2015, Michihiko Tonouchi of the project team installed a PC system for verification of INAM daily weather forecasts and storage of various SWFDP (Severe Weather Forecast Demonstration Project) products from the South Africa Weather Service (SAWS) and GPVs (grid point values) from the global numerical weather prediction model operated by the Japan Meteorological Agency

(JMA). As this system was not utilized effectively due to Internet connectivity issues, Kota Nakai implemented training on its practical use for three staff on the INAM C/P team immediately after his assignment on the third visit. The trainees learned to input daily observation data and daily weather forecast data for observation of verification results.

- Michihiko Tonouchi carried out training for verification of INAM daily weather forecasts upon his arrival for the assignment. As a result of the training, the INAM C/P team is developing a monthly weather report for Mozambique. Mr. Tonouchi also gave presentations and ran a discussion seminar on analysis and forecasting of extreme events for which INAM issues weather warnings in relation to heavy rain or thunderstorms. His input helped forecasters to understand the importance of recording data, analyzing extreme weather events and comprehending why certain phenomena occur. A presentation on the characteristics of clouds associated with heavy rain in meteorological satellite images was particularly well received. The related data and training materials are stored on a PC in the forecast room, and can be readily accessed at any time for research purposes. Further details are provided elsewhere in this report.

Activities of the 5th visit

Implementation of forecast briefing using a large display

The purchase of a large (42-inch) display was funded by JICA's Mozambique office at the end of January 2017. The display was installed in the forecasting room in collaboration with a variety of INAM personnel and used for daily morning forecast briefings under the instruction of Kiichi Sasaki from the 6th of February onward. Kota Nakai also attended these briefings when activity scheduling allowed, and provided advice on weather interpretation.

This briefings demonstrated a significant effect from the process of observation for the gradual development of a tropical depression generated in the Mozambique Channel on the 12th of February into Cyclone Dineo. Consequently, the timing and content of INAM's cyclone warning for the event was highly evaluated both by internal and external organizations. Kota Nakai produced a related article for the JICA Mozambique newsletter and conducted a questionnaire survey on Kiichi Sasaki's forecast briefing training with attending INAM forecasters. All respondents reported significant advantages from forecast briefings using the large display. Kota Nakai provided guidance to enable ongoing forecast briefings every morning once Mr. Sasaki's assignment ended.

(5) Questionnaire survey on INAM weather forecasts, advisories and warnings

Original plan

To determine degrees of recognition and adequacy in relation to weather forecasts, advisories and warnings (including tropical cyclone information), a JICA expert will conduct a paper-based questionnaire survey of disaster risk management organizations, media outlets and lifeline companies.

The questions will cover the following:

- Details/timing of INAM warnings
- Expectations of weather information users regarding INAM output

The project team will also conduct interviews with survey respondents.

During the second visit, Kota Nakai proposed the implementation of a questionnaire survey to determine the degree of adequacy of current INAM weather forecasts/warnings and related needs to allow future improvement of such content, and also set specific question items. INAM agreed to the proposal and carried out the survey in January 2016. INAM's question items were simplified in comparison to Mr. Nakai's proposal (Appendix H-2), but the fact that INAM produced the survey content itself is considered important.

Kota Nakai and Michihiko Tonouchi conducted interviews as visiting representatives of DNGRH (previously DNA), two newspaper companies and four TV companies in order to supplement the above questionnaire survey during the third visit. The main points for immediate assimilation by INAM are outlined below (for details, see Appendix H-3).

- DNGRH and other organizations have great trust in INAM's work.

- Weather forecasts and warnings sometimes arrive either late or not at all despite the establishment of e-mail and fax channels. Possible reasons include malfunction of the INAM system for weather information dispatch and delays in INAM forecasting work. Weather information arriving late cannot be used for TV broadcasts.

- The provision of weather advisories and warnings with fine detail from provincial to local district level would be extremely valuable.

- It is known that INAM produces video for TV weather information broadcasts every day. However, private TV companies may not use such output in their TV studios due to a preference for unique content for distinction from other broadcasters.

- The INAM STV resource is used. Regarding the issue of weather information not arriving on time, positive substitutional methods within INAM need to be established.

Kota Nakai updated INAM on the results of the interview survey toward discussions on improvement policy for weather advisories and warnings in line with related requests.

(6) Improvement of weather forecasts/warnings based on questionnaire results

Original plan

The JICA expert will create improvement plans for weather forecasts and warnings in collaboration with INAM. These plans will be both short- and medium-to-long in range, as the infrastructure-maintenance plan for forecasting work needs to be incorporated. INAM should re-examine these plans as appropriate and discern the degree of improvement achieved.

- On the 21st of March 2017, Kota Nakai made proposals on current problems to be addressed and mid-/long-term matters to be tackled by INAM, and held a frank meeting with directors and heads of each department of INAM (although the Director-General was absent due to attendance at an external meeting).
  The current problems highlighted by Mr. Nakai were based on matters previously discussed by team experts. Work on medium- and long-term matters was expected to serve as reference for new-project proposals to various donors such as JICA (see Appendix H-4).
- The directors and heads of individual INAM departments indicated their intention to make effective use of the proposal to improve meteorological observation, weather forecasts and warnings.

(7) Others

Presentation for junior INAM staff

- Kota Nakai gave a presentation titled “How should we work by seeing where?” on the 13th of March to help junior INAM staff perform their duties with high motivation. Mr. Nakai had initially planned two presentations, but eventually gave only one due to INAM internal factors. The content was based on deliveries given during his tenure with the Japan Meteorological Agency, and included distribution of updated materials for INAM (see Appendix H-5). While the evaluation of the 30 or so attendees necessarily differed due to cultural factors and occupation-related senses of values, Mr. Nakai was confident in the presentation’s general popularity.

Issuance of project newsletter

- To ensure significant progress with the project, it is important to have all INAM staff fully understand its nature and promote related collaboration. Against such a background, the JICA project team began issuing newsletters with the third visit and had published six volumes by March 2017 (see Appendix F).

3. 7 Equipment procurement

The expert team procured the following equipment necessary for implementation of the project activities. The equipment procured in Japan was transported to Mozambique and was handed over to INAM on the 29th of February 2016. A handover ceremony was held on the WMO-day of 21st March 2016 (Fig. 3-52). Hand-over papers are given in the attachment D.

Table 3-20 procured equipment 1

Handover date: 29 Feb 2016

No	Item	Qty	Purpose/Remarks	Specification	Remark
1	PC (laptop)	1 (J)	PC for inspection of local observatories' instruments	Windows, MS-office, anti-virus software	Toshiba dynabook RZ83/TB
2	Digital barometer (3 sensors)	1 (J)	National standard of INAM (calibrated at RIC Tsukuba)		Vaisala PTB-330TS, M170, HMP155 (3 sensors)
3	Digital barometer (1 sensor)	3 (J)	Parts of National standards of INAM (calibrated at RIC Tsukuba) For inspection of local observatories		Vaisala PTB-330TS, M170, (1 sensor)
4	Digital thermometer	3 (J)	National standards of INAM (calibrated at RIC Tsukuba)	Pt sensor	Anritsu Meter Co.,
5	Assmann	5 (J)	Calibration in INAM	Assmann aspiration psychrometer	Yoshino Keisoku Co.
6	Calibration goods for thermometer	1 (M)	Calibration in INAM	Water filter, ice flaker, cooler box	
7	Rain gage	5 (J)	Comparison of rain gage	Tipping bucket type, its base and data logger	
8	Rain gage calibration cylinder	1 (J)	Calibration of rain gage	Plastic Cylinder for rain gage	

9	PC (desktop)	1 (M)	Store satellite, NWP, charts, observation data Trail for weather guidance	Windows, MS-office, anti-virus software	Hewlett & Packard
10	Hard disk unit	1 (J)	Hard Disk storage unit (maximum for 5 HDs)	Century SATA6G	Not procured yet
11	Hard Disk	5 (J)	Data storage	SATA 4Tbyte	Not procured yet
12	Pressure adjustment pump	1	Barometer inspection (for output 1)	Equivalent of RIC Tsukuba	Daiichi Kagaku Type –V1
13	Pipe work, jigs and related parts	1	Barometer inspection (for output 1)	Equivalent of RIC Tsukuba	Daiichi Kagaku Pipe work, jigs and related parts
14	Liquid Bass Chamber	1	Temperature inspection	Temperature indication, setting of 1/100 °C	Thomas Co. Celsius 100L

(M) Procured in Mozambique
(J) Procured in Japan

Fig 3-52 Handover ceremony (from left: JICA expert, DG of INAM. Representative of JICA)

Fig 3-53 Inspection of calibration equipment by the Minister of Transport and Communication

With the change of project activities for the enhancement of capacities in weather forecasting and warnings from radar to satellite and AWS, the expert team procured rain gages data loggers and modems in Japan, and transported to Mozambique in September 2016. The team installed three AWSs at Nampula, Beila and Maputo airports. In addition, thermometers and Hygrometers were added to the airport stations in January 2017. These instruments (Table 3-21) were handed over to INAM at the JCC on the 7th of July 2017.

Table 3-21 procured equipment 2 (AWS)

Handover date: 7 July 2017

No	**Item**	**Qty**	**Purpose/Remarks**	**Specification**	**Remark**
15	Data logger (J)	3	Data logger (data storage and data communication) and battery 15Ah	TCP/IP socket and ftp	Campbell data logger CR800
16	Modem (j)	3	Data communication	GSM modem	CSN-3GR
17	Solar battery panel (J)	3	Electricity provision (DC-17V)	12W, 17V With attachment	
18	Logger box (J)	3	Box for logger, battery, modem and related gears		C-ENC14-MM

19	Thermometer (J)	3	Thermometer (Pt-100)	With JMA verification	C-HPT-10－JM Cable 10m
20	Hygrometer (J)	3	Pt-thermometer and capacitance hygrometer (output 0-1V)	With JMA verification	CVS-HMP155D-10-JM (Vaisala) Cable 10m

(J) Procured in Japan

Table 3-22 JMA Calibration Number

Handover date: 7 July 2017

		Rain gage	Thermometer	Hygrometer
		Takeda Keiki TKF-1UD Type Calibration 10507	C-HPT-JM	Vaisala HNP155
Nampula	Calibration Number	15219 (2015.07)	1611-06(2016.10)	M4710319(2016.11)
	INAM-check-sheet		No.1(check sheet)	
Beira	Calibration Number	15217(2015.07)	1611-05(2015.10)	M4710320(2015.11)
	INAM-check-sheet		No.2(check sheet)	
Maputo	Calibration Number	15218(2015.07)	1611-04(2015.10)	M4710321(2015.11)
	INAM-check-sheet		No.3(check sheet)	

3. 8　Training in Japan

3. 8. 1　Verification and Maintenance of Meteorological Instruments

(1) Outline of training in Japan

(a) Training course

Verification and Maintenance for Meteorological Instrument (J1522000)

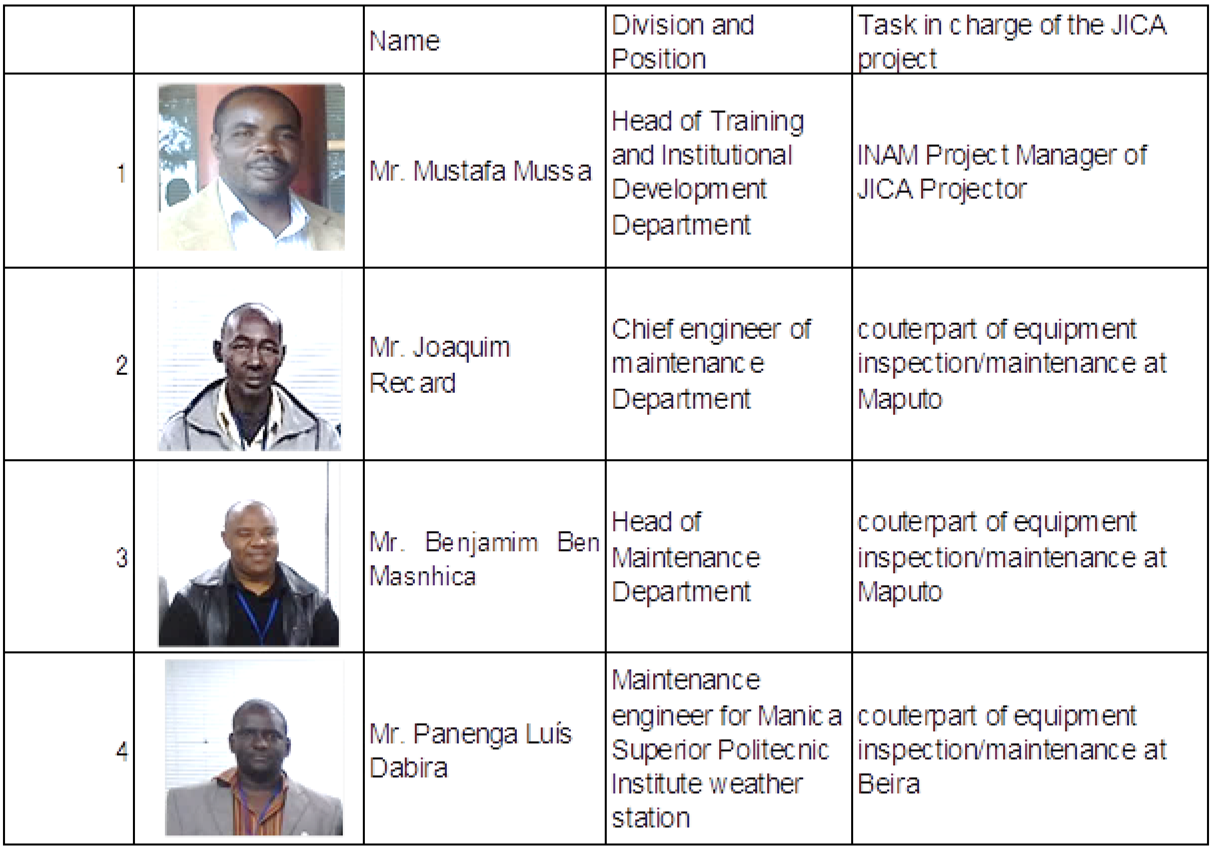
(b) Period

1st to 11th of December 2015

(c) Trainees

4 INAM staff members

Table 3-23　Attendees
'Verification and Maintenance of Meteorological Instruments'



		Name	Division and Position	Task in charge of the JICA project
1		Mr. Mustafa Mussa	Head of Training and Institutional Development Department	INAM Project Manager of JICA Projector
2		Mr. Joaquim Recard	Chief engineer of maintenance Department	couterpart of equipment inspection/maintenance at Maputo
3		Mr. Benjamim Ben Masnhica	Head of Maintenance Department	couterpart of equipment inspection/maintenance at Maputo
4		Mr. Panenga Luís Dabira	Maintenance engineer for Manica Superior Politecnic Institute weather station	couterpart of equipment inspection/maintenance at Beira

(2) Details of training

(a) Purposes and targets

In Mozambique, the National Institute of Meteorology (INAM) operates under the Transportation and Telecommunication Agency to provide weather observation and forecasting services. To support the issuance of precise weather warnings, technical transfer to core staff of

INAM’s Inspection and Maintenance Department is needed toward verification and maintenance of meteorological instruments for accurate observation. To strengthen the expertise of these staff, technical transfer activities for those posted at headquarters and local observatories is implemented. The accurate observation data resulting from such efforts is expected to contribute to appropriate forecasting and disaster risk reduction (DRR).

Based on the World Weather Watch program, the World Meteorological Organization mandates the sharing of accurate weather observation data collected using verified weather equipment among national weather services to support monitoring of potential natural disasters and issuance of appropriate warnings for DRR. Based on WMO requirements for traceability against international standards, ongoing accuracy of weather instruments and appropriate equipment maintenance, this training at JMA’s Regional Instrument Center Tsukuba is designed to build inspection, calibration and maintenance expertise in relation to meteorological equipment. The targets of the training were:

(i) Build capacity for accurate observation (maintenance of equipment accuracy and traceability against international standards) and upkeep of the inspection/maintenance structure.

(ii) Build capacity for instrument calibration and production of equipment correction tables, and highlight the importance of regular maintenance and regular procedures to support accurate meteorological observation.

(iii) Build awareness of the principles of meteorological equipment and maintenance.

(iv) Build expertise in the implementation of technical instruction activities at local observatories.

The training was designed to achieve these targets via activities including exercises on equipment calibration and inspection, presentations on natural disaster prevention work in Japan, tours of inspection facilities, observation, forecasting, radar data usage and issuance of weather information

(b) Schedule

Table 3-24 Verification and Maintenance of Meteorological Instruments training schedule

No.	Date			training contents	Lector	Place		Place	Accomodation
				3 INAM maintenance officers			1 administrative manager		
1	2015/11/29	Sun		Travel (Maputo -> Tokyo)					
2	2015/11/30	Mon		Travel (Maputo -> Tokyo)			same as other members		JICA Tsukuba
3	2015/12/1	Tue	AM	JICA briefing	JMA/JMBSC	RIC tsukuba and JMA HQ			JICA Tsukuba
			PM	A short tour to JMA headquarter (observation dep., forecast dep., earthquake & volcano dep.)					
4	2015/12/2	Wed	AM	Lecture: RIC activities, Actinometer traceability	JMA/JMBSC	RIC tsukuba			JICA Tsukuba
			PM	Rain gage inspection section					
5	2015/12/3	Thu	AM	Thermometer traceability	JMA/JMBSC	RIC tsukuba			JICA Tsukuba
			PM	Thermometer comparison with a travel standard.					
6	2015/12/4	Fri	AM	Barometer traceability	JMA/JMBSC	RIC tsukuba			JICA Tsukuba
				Barometer comparison with a travel standard.					
			PM	Inspection for Wind tunel chamber					
				Thermoter/Rain gage traceability					
7	2015/12/5	Sat		Preparation and documentation		JICA Tsukuba			JICA Tsukuba
8	2015/12/6	Sun		Preparation and documentation		JICA Tsukuba	Travel [Tokyo-Kyoto]	JICA Tsukuba/ Kyoto	
9	2015/12/7	Mon		A exercise calibration and comparison (thermometer 1)	JMBSC	JMBSC instrument dep.	Doshisya Univ or Kyoto Univ.	Doshisya Univ.	JICA Tsukuba/ JICA Kobe
							Meeting with Luisa Adriano Chanque		
10	2015/12/8	Tue		A exercise calibration and comparison (thermometer 2)	JMBSC	JMBSC instrument dep.	ADBR	ADBR	JICA Tsukuba/ JICA Tokyo
							Travel [Kyoto-Tokyo]		
11	2015/12/9	Wed		A exercise calibration and comparison (barometer 1)	JMBSC	JMBSC instrument dep.	JMA observation system and structure	JMBSC	JICA Tsukuba/ JICA Tokyo
							JMA weather forecast and warnings system and structure		
12	2015/12/10	Thu	AM	A exercise calibration and comparison (barometer 2)	JMBSC	JMBSC instrument dep.	Disaster Rsik Reduction program of WMO	JMBSC	JICA Tsukuba
			PM	Thermometer comparison with Assmann psychrometer			JMA activities for DRR past 70 years		
13	2015/12/11	Fri	AM	Exercise: Making inspection and maintenance manual	JMBSC	JMBSC instrument dep.	same as other members		JICA Tsukuba
			PM	Final reporting and ceremony for Certification					
14	2015/12/12	Sat		Travel (Tokyo to Maputo)					
15	2015/12/13	Sun		Travel (Tokyo to Maputo)					

RIC: Regional Instrument Center
JMBSC: Japan Meteorological Business Support Center
ADRC: Asian Disaster Reduction Center

(c) Curriculum

Table 3-25 Verification and Maintenance of Meteorological Instruments training curriculum.

Style	Duration	Detailes	Provider	Venue
Presentation	4 hours	Outline of JMA activities	JMA HQ	JMA HQ
Inspection		Inspection of JMA forecast operation room	JMA HQ	JMA HQ
Inspection		Inspection of JMA observation operation room	JMA HQ	JMA HQ
Inspection		Inspection of Kitanomaru-observatory	JMA HQ	Kitanomaru
Presentation	2 hours	Outline of RIC Tsukuba, automatic observation, surface observation, observation field, calibration, inspection, maintenance and trouble shooting	RIC Tsukuba	RIC Tsukuba
Inspection	3 hours	Inspection of RIC Tsukuba ad ozone sonde observation	RIC Tsukuba	RIC Tsukuba
Presentation, inspection	2 hours	Principles of thermometers and traceability (inspection of inspection devices)	RIC Tsukuba	RIC Tsukuba
Exercise	2 hours	Calibration with traveling standards (thermometers)	JMBSC	RIC Tsukuba
Inspection	1 hour	Inspection of upper-air observatory and Meteorological Research Institute	RIC Tsukuba	RIC Tsukuba
Presentation	1 hour	Principles of barometers and traceability (inspection of inspection devices)	RIC Tsukuba	RIC Tsukuba
Inspection	1 hour	Calibration with traveling standards (barometers)	JMBSC	RIC Tsukuba
Inspection	2hours	Inspection of wind tunnel (anemometer inspection and traceability)	RIC Tsukuba	RIC Tsukuba
Presentation		Principles of rain gauges/hygrometers and traceability (inspection of inspection devices)	RIC Tsukuba	RIC Tsukuba
Inspection	1.5 days	Calibration of glass thermometers (inspection of ice point and usage of FTL sink)	JMBSC	JMBSC
Presentation	3 hours	Barometer calibration exercise	JMBSC	JMBSC
Exercise	2 hours	Exercise for cleaning and reframing of Assmann aspiration psychrometer	JMBSC	JMBSC
Exercise	3 hours	Exercise for calibration using Assmann aspiration psychrometer	JMA HQ	RIC Tsukuba
Inspection, discussion	2 hours	Research plan discussion at Doshisha University	Prof. Yamane	Doshisha-University
Inspection	3 hours	Inspection of JMA Osaka regional office	JMA HQ	JMA Osaka office
Inspection	2 hours	Inspection of Asian Disaster Reduction	Kota Nakai	Kobe City

		Center		
Presentation	2 hours	Weather observation system	JMBSC	JMBSC
Presentation	3 hours	Radar products and related usage for weather forecasting	JMBSC	JMBSC
Presentation	2 hours	DRR (WMO Disaster Risk Reduction program of WMO	JMBSC	JMBSC
Presentation	2 hours	Weather warnings and activities for DRR	JMBSC	JMBSC

(3) Training output

(a) Output

The trainees gained expertise and experience regarding the purposes and targets of the training. Attainment of the targets can be summarized as follows:

(i) Build capacity for accurate observation (maintenance of equipment accuracy and traceability against international standards) and upkeep of the inspection/maintenance structure.

Trainees solidified their awareness of meteorological equipment inspection and verification of accuracy/traceability structure, and also understood chains of INAM equipment traceability destruction and related countermeasures.

(ii) Build capacity for instrument calibration and production of equipment correction tables, and highlight the importance of regular maintenance and regular procedures to support accurate meteorological observation.

Through hands-on exercises in equipment calibration, trainees learned/reviewed actual calibration processes. Other exercises highlighted appropriate maintenance procedures. Toward the maintenance of a stable inspection/calibration/maintenance structure, ongoing follow-up training should be implemented for review.

(iii) Build awareness of the principles of meteorological equipment and maintenance.

Through the presentations of the first week, trainees built awareness and were provided with educational materials for use in internal training at INAM.

(iv) Build expertise in the implementation of technical instruction activities at local observatories.

Trainees were provided with materials/ideas for internal training and presentations at INAM.

(b) Future plans

Future activity plans relating to the training targets are as follows:

(i) Build capacity for accurate observation (maintenance of equipment accuracy and traceability against international standards) and upkeep of the inspection/maintenance structure.

Follow-up training to be provided by the expert was scheduled for February 2016 and by RIC-Tsukuba experts for August 2016 to review matters of technical expertise and strengthen related structure.

(ii) Build capacity for instrument calibration and production of equipment correction tables, and highlight the importance of regular maintenance and regular procedures to support accurate meteorological observation.

Experts review equipment calibration and activities for the production of correction tables during their visits, discuss/draft regular maintenance plans for INAM with C/Ps, and implement OJT in line with these plans using manuals.

(iii) Build awareness of the principles of meteorological equipment and maintenance.

The materials used in the training were shared among INAM staff and made available for INAM observer training for 40 staff in summer 2016.

(iv) Build expertise in the implementation of technical instruction activities at local observatories.

Implementation of OJT at local observatories is also planned.

3. 8. 2 Weather Forecasting and Warnings

(1) Outline of training in Japan

(a) Training course

Weather Forecasting and Warnings

(b) Period

21st of November to 2nd of December 2016

(c) Trainees

4 INAM staff

Table 3-26 Weather Forecasting and Warnings trainees

		Name	Division and position
1		DOMINGOS Aurelio Jorge Victor	Head of Aeronautical Support Center, Weather Forecast Department, INAM
2		QUISSICO Daniel Zefanias	Provincial Delegate, Gaza Province Delegation, INAM
3		MANJATE Guels Mauro Armnado	Forecaster, Weather Forecast Department, INAM
4		ALBERTO Queiroz	Forecaster, Weather Forecast Department, INAM

(2) Details of training

(a) Purposes and targets

In Mozambique, the National Institute of Meteorology (INAM) is responsible for issuing weather forecasts and warnings. Enhancement of capabilities in these areas at INAM is a project purpose, but the organization’s systems for the provision of meteorological information to support disaster prevention activities are inadequate. Weather forecasting techniques based on observational and numerical prediction data also require improvement.

The main purpose of this training is to enhance the ability of forecasters by giving a comprehensive overview of the advanced meteorological services provided by the Japan Meteorological Agency (JMA), including its structure for weather forecasting and warnings, observational data and NWP data used for operational forecasting, and dissemination of meteorological information to users.

The targets of the training were:

i) Build awareness of how forecasts and warnings issued by meteorological authorities are used for related disaster prevention activities.

ii) Build awareness of the types and content of observation/forecast data required for effective production of forecasts and warnings.

iii) Build awareness of effective systems for issuance and dissemination of forecasts and warnings to users.

The training was designed to achieve these targets via activities including presentations on JMA's observation, forecasting and disaster prevention services, technical visits to JMA headquarters, regional headquarters, local meteorological offices and related authorities, and exercises on weather forecasting and forecast guidance. It is expected to improve forecasting expertise and understanding among forecasters to support future INAM metrological services.

(b) Schedule

Table 3-27　Weather Forecasting and Warnings training schedule

No.	Date		Contents		Lecturer	Place	Accommodation
1	2016/11/19	Sat		Travel (Maputo -> Tokyo)			
2	2016/11/20	Sun		Travel (Maputo -> Tokyo)			JICA Tokyo
3	2016/11/21	Mon	AM	JICA briefing		JICA Tokyo	JICA Tokyo
			PM	Lecture1: Met services of JMA, JMA's observation system（13:45—16:30）	Sasaki, Jomura （JMBSC）	JMBSC	
4	2016/11/22	Tue	AM	Lecture2: JMA's forecasting system, DRR in Japan（13:45—16:30）	Sasaki, Yokoyama（JMBSC）	JMBSC	JICA Tokyo
			PM	Technical tour1：JMA Headquartes、Observation field（13:45—17:15）	JMA Headquarters	JMA・Headquarters	
5	2016/11/23	Wed		(Hato-bus tour)			JICA Tokyo
6	2016/11/24	Thu	AM	Technical tour2: Maebashi LMO（10:30—12:00）	Maebashi LMO	JMA・Maebashi LMO	JICA Tokyo
			PM	Technical tour3: Maebashi City（13:30—16:00）	Maebashi City	Maebashi City Office	
7	2016/11/25	Fri	AM	Lecture3: Introduction to satellite services（10:00—12:00）	MSC	JMA・Meteorological Satellite Center	JICA Tokyo
			PM	Technical tour4: Meteorological Satellite Center（13:30—15:30）	MSC		
8	2016/11/26	Sat		Preparation			JICA Tokyo
9	2016/11/27	Sun		Travel (Haneda-Sapporo)			JICA Sapporo
10	2016/11/28	Mon	AM	Technical tour5: Hokkaido Broadcast（10:00—12:00）	Hokkaido Broadcast	Hokkaido Broadcast	JICA Sapporo
			PM	Technical tour6: Sapporo Regional Headquarters（13:15—17:00）	Sapporo RHQ	JMA・Sapporo R_HQ	
11	2016/11/29	Tue	AM	Travel (Sapporo-Haneda)			JICA Tokyo
			PM	Technical tour7: NHK（13:30—15:00）	NHK	NHK	
12	2016/11/30	Wed	AM	Exercise1: :Weather forecast and warning （09:45—12:00）	Sassaki（JMBSC）	JMBSC	JICA Tokyo
			PM	Lecture4: Weather radar（13:30—16:30）	Makihara（JMBSC）		
13	2016/12/1	Thu	AM	Exercise2: :Weather forecast and warning （09:45—12:00）	Sasaki（JMBSC）	JMBSC	JICA Tokyo
			PM	Lecture5: Forecast guidance（13:30—16:30）	Taira（JMBSC）		
14	2016/12/2	Fri	AM	Evaluation meeting, Closing ceremony		JICA Tokyo	JICA Tokyo
15	2016/12/3	Sat		Travel (Tokyo to Maputo)			
16	2016/12/4	Sun		Travel (Tokyo to Maputo)			

(3) Training output

(a) Output

To enhance capacity for weather forecasting and warnings, the trainees gained expertise and experience regarding the purposes and targets of the training. Attainment of the targets can be summarized as follows:

i) Build awareness of how forecasts and warnings issued by meteorological authorities are used for related disaster prevention activities.

Trainees learned about the utilization of meteorological information for disaster prevention activities through presentations and technical visits to Sapporo regional headquarters, the Maebashi local meteorological office, the Maebashi municipal government and TV stations.

ii) Build awareness of the types and content of observation/forecast data required for effective production of forecasts and warnings.

Trainees learned about the types of observation and forecast information required for the production of forecasts and warnings through related presentations and exercises and through technical visits to JMA headquarters, regional headquarters and local meteorological offices.

iii) Build awareness of effective systems for issuance and dissemination of forecasts and warnings to users.

Trainees learned about JMA structures and systems used to disseminate appropriate meteorological information to users in a timely manner through presentations and technical visits to JMA headquarters, regional headquarters, local meteorological offices, disaster prevention authorities and TV stations.

(b) Future plans

Future activity plans relating to the training targets are as follows:

i) Build awareness of how forecasts and warnings issued by meteorological authorities are used for related disaster prevention activities.

The expert team and the JICA expert provided ongoing support for dialogue with the media and authorities concerned in Mozambique.

ii) Build awareness of the types and content of observation/forecast data required for effective production of forecasts and warnings.

The expert team conducted forecast OJT during the 2016/2017 rainy season and plans further OJT in the coming rainy season. Follow-up training was implemented as part of forecast OJT.

iii) Build awareness of effective systems for issuance and dissemination of forecasts and warnings to users.

The expert team and the JICA expert provided support for the improvement of forecasting/warnings and dissemination systems based on interview surveys with the media and disaster prevention authorities in Mozambique.

Chapter 4. Project Review

The purpose of the project is to enhance INAM meteorological observation, weather forecasting and warnings, and the overall goal is to enhance capacity for response to natural disasters in Mozambique.

The policies of the project's technical transfer involve (i) transfer of JMA expertise in disaster risk reduction to INAM, and (ii) documentation of INAM expertise (team goal: to improve INAM expertise via documentation of expertise and experience in meteorological observation, forecasting and warnings).

INAM's situation at the beginning of the project was sub-optimal as detailed in the baseline survey report; radar review had not been implemented, GTS (Global Telecommunication System) operation had been suspended due to communication line failure, and the satellite receiving system and SADIS (the SAtellite Distribution System) did not work properly. However, INAM implemented daily observation and forecasting using data obtained online, and their activities were implemented quite stably.

This project involves two outputs. Output 1 is technical expertise transfer for surface observation, radar operation/maintenance and enhancement of equipment traceability, and Output 2 is technical expertise transfer for weather forecasting and warnings. Regarding Output 1, observation at the beginning of the project (except the radar variety) was mostly implemented based on WMO guidelines. It was expected that team efforts to reintroduce INAM standards and calibration equipment (e.g., chambers) along with technical transfer training would help to eliminate gaps in the traceability chain. Improvement of manuals for observation and maintenance based on INAM activities was also expected to improve observation expertise and result in the production of related documentation.

However, the review of the Beira and Xai-Xai radars scheduled by the World Bank had not been implemented, and there was no prospect of restoring radar operation. In the area of forecasting, INAM could not use radar data, NWP data (obtained through a GTS line) or EUMETSAT data (obtained through a satellite data receiving system donated under the PUMA project). Activities with the relevant staff initially produced only limited progress toward the target project outputs.

For Output 1 (except radar), in line with the work plan, INAM standard barometers and thermometers were procured in Japan, and an inspection of JMA's RIC Tsukuba facility (a WMO Regional Instrument Center) was conducted as part of training in Japan. After shipment to Mozambique, the equipment was set up in the INAM laboratory and the trainees reviewed the inspection procedure in follow-up training provided by a JMA short-term expert/traceability expert. Repetition of the inspection procedure resulted in the comprehensive transfer of technical expertise on traceability to INAM. The observation expert developed manuals on surface observation, principles of meteorological equipment, observation procedures and methods for comparison with standards in reference to WMO guidelines and related materials. The expert also gave presentations at headquarters in 2016 and local observatories in 2017 using this documentation. Through these activities, technical expertise for observation was transferred to INAM headquarters and, to a certain extent, to local observatories. The related documentation has been made available to INAM for future activities in all local observatories to help improve observation procedures and accuracy.

Technical transfer for Output 1 has been mostly implemented, and documents for further improvement have been developed. Meanwhile, manned observation should also be shifted to automatic observation for future improvement. INAM must prepare this switch, not least because WMO recommends that NHMS (the National Hydro-Met Service) should stop using mercury equipment for pressure and thermometer observation based on the Minamata Treaty. When INAM shifts to automatic observation, the standards and chamber introduced under the project will become fully utilized and traceability to local observatories will be enhanced.

In regard to AWS (automatic weather station) introduction, the World Bank had planned a nationwide network consisting of rain gauges, river level meters and other equipment. However, as the plans have seen limited progress, the launch of such a network cannot be expected anytime soon. However, the project did result in the experimental installation of three AWSs in Maputo, Beira and Nampula to monitor heavy rain. The systems work properly and collect data steadily at 10-minute intervals. These data are monitored by the Maputo and Beira Observation/Forecasting Division for observation of heavy-rain events and temperature, and the situation sets a precedent for future AWS network implementation.

In this project, the focus of technical expertise transfer was changed from radar to satellite and AWS, and three AWSs were installed at Maputo, Nampula and Beira. On a maintenance trip to Beira in March 2018, Mr. Panenga of the Beira Observatory requested the following processes for AWS installation to strengthen technical expertise in AWS setting:

1. Design of AWS equipment and network by C/P and expert
2. Technical training for C/P by manufacturer
3. AWS installation at sites by C/P with support from expert and manufacturer
4. AWS network management by C/P with suggestions for improvement by expert

.

In this project, network problems and limited INAM engineer resources meant that the team could not implement work based on the above processes. However, these are considered ideal for technical transfer from experts to the C/P, and should be noted for technical transfer to INAM in next project phase.

Concerning the radar system, technical transfer for radar observation/maintenance/forecasting was excluded because the radars would not be repaired during the project period. However, the radar system plays an important role in the monitoring of actual precipitation and short-range forecasting of rain. Toward the resumption of radar observation, (i) a stable commercial electric power supply (ideally a separate power line and an electric substation on site) and (ii) a stable data communication line for data dispatch from the site to Maputo are important in enabling successful radar review.

For Output 2, as radar, EUMETSAT and GTS were not in use, the team implemented a survey to track INAM forecast activities and set materials for forecast/warning procedures. The survey results indicated that INAM collected materials for forecasting via the Internet and implemented daily tasks effectively. With this in mind, the team planned to store materials for forecasting and implement forecast evaluation with implementation of post-event reporting based on discussions with INAM forecasters as a way of documenting related expertise. Work on the project provided the following positive results.

- INAM has kept PC records of forecast, warning and observation reports since 2014. These electronic data provide significant support for verification/evaluation activities. Digital data gaps are filled with information from paper-based reports.
- The SWFDP (Severe Weather Forecasting Demonstration Project) implemented by the South Africa Weather Service and weather charts produced by ECMWF/UK-Met-Office/South Africa Weather Service/JMA are provided online, and INAM can use these resources to execute daily tasks.

As weather forecasters in Japan use digital data (radar, satellite and NWP) mainly for quantitative forecasting (i.e., time-sequence city-level predictions), technical expertise transfer under the project includes quantitative forecasting. Meanwhile, the team found out that INAM provided forecasts and warnings to governmental bodies and related organizations using information from the Internet. The team changed its technical transfer procedures to match to the realities of INAM’s forecasting procedure, resulting in the implementation of more appropriate transfer. As mentioned above, technical expertise is shared and transferred through activities such as the team’s implementation of forecast material storage, forecast evaluation every Tuesday, and post-event analysis. Additionally, with the change of the technical expertise transfer target to satellite and AWS data usage, technical expertise for heavy-rain monitoring with satellite and AWS was enhanced through OJT and briefings.

The satellite expert implemented OJT for monitoring/forecasting of extreme phenomena in the 2016/17 and 2017/18 rainy seasons. Based on this work (and in particular the presentations/discussions conducted during the briefings), INAM forecasters issued an early warning for Cyclone Dineo with appropriate lead time, shared expertise and discussed heavy-rain events and further sharing of forecasting expertise. Through the project, INAM forecasters took the first step toward integrated forecasting using numerical weather prediction, meteorological satellite data and AWS.

The satellite expert also introduced weather guidance (for temperature using the Kalman filter method) and the team experimentally developed maximum/minimum temperature guidance and forecaster support products (daily weather and wind forecasts) in conjunction with NWP. These experiments were still being conducted by C/Ps as of June 2018. In all forecast-related targets, the team achieved higher levels of technical expertise transfer than originally planned.

Issues in project implementation, related ideas and lessons learned from the project are summarized in Table 4-1.

Table 4-1 Issues in project implementation, related ideas and lessons learned from the project

Issue	Idea	Lesson
Shortage of INAM standard equipment and disconnection of traceability	Installation of standard equipment and transfer of technical expertise through training in Japan and on site with RIC Tsukuba under the project	Effective transfer of technical expertise between NHMSs was possible under international cooperation scheme arrangements.
Equipment traceability not connected to local observatories	Development of manuals and documents for training and implementation of presentations/exercises at headquarters and certain local observatories	Traceability connection to local observatories is difficult for manned observation equipment. The situation will be improved with AWS system installation.
Radar not rehabilitated and not in operation	Switch of project target focus to satellite and AWS	For advanced technology observation systems, a stable environment (electricity and

		communication) and management expertise are required.
NWP and satellite data not delivered to INAM	Along with INAM daily tasks, team storage of materials for forecasting and implementation of technical expertise transfer	Technical expertise transfer along with INAM daily tasks was effective and fitting for appropriate technical transfer to the C/P.
Forecasts and warnings recorded but not reviewed	Team implementation of forecast/warning evaluation using related records	Forecast/observation data storage and related usage are quite important for technical transfer.
Daily weather analysis (weather briefings) not implemented	Satellite expert implementation of briefings and contribution to early/appropriate cyclone warning issuance during the 2016/17 rainy season	The special forecast/warning team formed under the project contributed to technical transfer activities.
Qualitative weather forecasting dependent on each forecaster's experience and knowledge	Technical expertise transfer of temperature guidance and daily forecast support material with GPV data, sharing of knowledge among forecasters through weather briefings	Forecast OJT in the forecasting operation room built trust relationship with C/P that led to sharing knowledge and to a trial of new techniques.

Chapter 5. Recommendations for Overall Goal Achievement

Overall goal and project goal of the project are as follows.

[Overall Goal]

Capacities to respond the natural disasters are enhanced in Mozambique

[Project Purpose]

INAM is capable to issue improved weather forecasts and warnings by using quality-controlled meteorological data.

Through the project, traceability and observation accuracy are improved with installed standards and lectures, and forecast skills are also improved with verification and OJT activities. INAM has been able to issue cyclone early warnings, therefore Project Purpose has basically been achieved.

For achievement of overall goal of the project, INAM needs to initiate additional activities, in addition to continuation of current activities. The team recommends following terms, in order to sustain the achieved Project Purpose, and to deal with newly arising issues.

(1) Recommendations to sustain the achievement of the project purpose

(a) Enhancement of meteorological observation capacity at INAM

For stable and improved surface observations by INAM, following activities are required:

- To ensure and maintain the traceability of meteorological instruments

  INAM standards need to be calibrated at least once a year. The traceability of other traveling standards and similar based on mutual calibration within INAM will be established through individual and alternate calibration at all stations. Meteorological instruments other than barometers and thermometers will also need to be established traceability. Inter-comparison of meteorological instruments need to be conducted to assure observation accuracy as well as to improve techniques for traceability. Calibration results need to be documented and stored appropriately for at least 10 years.

- To regularly maintain local stations

  To confirm that all instruments in local stations are calibrated, INAM Central Office maintenance department needs to formulate long-/short-term maintenance plans and carry out routine maintenance. INAM local stations should record daily/weekly check notes proposed under the project.

- To review nationwide observation network

  Manned observations are mainly conducted by INAM at present. WMO recommends renewal of mercury barometers to electric barometers, and glass thermometers will most likely be shifted to electric sensors in the future. In order to correspond to these, INAM should review and revise nationwide observation network (including combination of AWS and manned observations, etc.) and establish traceability of AWS.

- To develop capacity of observers

  Trainings and continuous improvement of capacity of observers are indispensable to confirm that observers comply with observation basics and guidance. Observer training at INAM is currently limited for new staff, and periodical training should also be added for experienced observers. Additional training should be carried out when new instruments such as AWS are installed.

- To collaborate with other organizations

  Stable communication is required to send observation data. Stable power supply is indispensable for weather radar operation. To improve its operation conditions, INAM will need to collaborate with external organizations concerned such as aviation meteorological agencies and mobile phone companies.

(b) Enhancement of forecasting and warning capacity at INAM

Continuous efforts in weather forecast evaluation, post-event verification, briefings on weather analysis/forecasting and weather guidance experiments are essential for the development and improvement of INAM forecast/warning expertise. The following activities are required:

- Accumulation of data

  High resolution digital data such as GPV and satellite images are necessary, however INAM has not been able to stably receive these data due to unstable GTS connections. Stabilization of communication is required through further collaboration with ICT section and observation department.

- Forecast evaluation and post-event verification

  INAM needs to validate its observed data and forecasts, and evaluate its forecast accuracy, in order to improve its forecast procedures. Post-evaluation of extreme weather events and warnings, compiled to monthly reports will improve capacity of forecasters. Installation of AWS in 3 locations (Maputo, Beira, and Nampula) enabled real-time observation and verification of weather conditions.

- Briefings

  A large display was installed in the forecasting room, which enabled easier information sharing and discussion among forecasters. Such work promotes steady development of expertise and sharing of awareness among forecasters of all ages.

- Forecast guidance

  Forecast guidance introduced in the project is an important technique to provide understandable forecast information to users. The trial operation of temperature guidance is continuing at the end of this project. It is expected that INAM continues the trial and use forecast guidance in an operational basis in the future.

(2) Recommendations for new items

Though these were not included in the Project components, some issues have been identified necessary for INAM to tackle in the future, in order for INAM to achieve the Overall Goal. The team recommends the following actions:

(a) Knowledge and technique development to adapt to new technologies

After 3 pilot AWS were installed, the following processes required for AWS expansion were identified: 1) design of AWS equipment and network, 2) technical training to INAM on installation of AWS by manufacturer, 3) installation of AWS by INAM, 4) AWS network management by INAM with support for improvement by experts. There are plans by the UK to support AWS installation; therefore capacity building and technical transfer to INAM engineers are essential to ensure proper maintenance. Both INAM and donors should work together on network design, setting, installation and operation of the network.

(b) Improvement of network environment and improvement of ICT department

The network environment in INAM is still weak to accommodate the new ICT system for observation and forecast. Improvement of ICT techniques is one of the urgent issues to overcome technical stagnation of INAM. Additional recruitment of young ICT technicians and restructuring of ICT section are needed.

(c) Information dissemination

Some extreme weather events were identified as difficult to predict within a two-to-three-day lead time. INAM needs to coordinate with other government bodies and media outlets to establish additional measures to disseminate urgent information to the public.

At the March 2018 seminar, representatives from the media and government bodies made comments and suggested improvements for INAM forecasting and warnings. Such opportunities are important for INAM to reach out to the users to learn about their expectations.

(d) Increase of Technical staff

Human resource development and management of technical capability are needed for maintenance and operation of new meteorological equipment such as AWSs and radars. The current INAM staff and structure are not sufficient and additional technical staff is indispensable.

Chapter 6. Achievement of Project Purpose

6. 1 Major achievements and levels of achievement for individual indicators

The project for capacity enhancement in meteorological observation, weather forecasting and warnings in the Republic of Mozambique was started in April 2015 with close collaboration between the country's National Institute of Meteorology (INAM) and the Japan International Cooperation Agency (JICA). Since the beginning of the project, various activities for meteorological observation (Output 1) and weather forecasting and warnings (Output 2) have been implemented. Major achievements and related remarks are summarized in Table 6-1 (for Output 1) and Table 6-2 (for Output 2).

In the area of meteorological observation, although indicator 1-2 (radar observation) was not achieved due to an unexpected delay in the recovery of the Beira and Xai-Xai radars, other indicators concerning traceability, surface observation and meteorological satellite data were mostly favorable.

Table 6-1 Major Achievements of Output 1

Output 1 (Capacities in meteorological observation at INAM are enhanced)	
Indicators	Major achievement
1-1. Developed guidelines and manuals for the traceability and inspection of meteorological instruments.	▪ The expert team drafted guidelines for calibration and inspection of meteorological instruments and a maintenance manual for meteorological instruments based on the results of the baseline survey, the INAM inspection manual and the JMA guidelines. Exercises with the guidelines and the manual were conducted several times at INAM and local stations. ▪ The guidelines and the manual have been appropriately updated in collaboration with the INAM C/P. [Remarks] ▪ Indicator 1-1 was achieved. ▪ Technical transfer on meteorological instrument traceability and inspection was mostly complete. INAM should hold regular training sessions based on the guidelines/manual for relevant staff at INAM and local stations in the future.

1-2. Developed guidelines for the quality control of meteorological radar data and checkup list for meteorological radar. (original in November 2014)	・ Based on the results of the 2015 field survey on the status of the Beira and Xai-Xai radars, the expert team made a recommendation to INAM for related improvement. However, rehabilitation of the Xai-Xai radar during the project period appeared impractical. The expert team also urged INAM to improve the electric power supply to the Beira radar site.. ・ Commercial electric power is now supplied to the Beira radar, but the proposed improvement of electric substation equipment has not been implemented. As a result the resumption of radar operation appears impractical. Accordingly, the expert team proposed changing the focus of technical transfer from radar to satellite at the JCC meeting in September 2016 [Remarks] ・As operation of the Beira and Xai-Xai radar was not implemented, indicator 1-2 (Radar) was not achieved. ・ INAM wishes to renovate its weather radars, but electric power supply conditions should be improved first.
1-2. Developed guidelines for the monitoring heavy rain with satellite data and ARG (Automatic Rain Gauge) data. (modified in November 2016)	・ The expert team installed JMA's SATAID automatic downloader for EUMETSAT satellite images on INAM PCs and carried out presentations and exercises for heavy-rain monitoring and satellite image analysis with SATAID. ・ Preliminary evaluation of potential heavy-rain areas estimated from satellite data with ARG installed at three airports through the project revealed the effectiveness of ARG data. [Remarks] ・ Indicator 1-2 (satellite) was mostly achieved. ・ As satellite-based quantitative precipitation estimates should be calibrated with ARG data, at least one ARG for each province of installation is required for heavy-rain monitoring with satellite data.

1-3. Training on meteorological observation is conducted for at least 3 INAM staffs in charge for operational observation/calibration.	・ Presentations and exercises on meteorological observation in accordance with the guidelines and the manual were conducted several times at INAM and local stations, and INAM staff improved their understanding of meteorological observations as a result. ・ Four INAM staff took the training on calibration and maintenance for meteorological instruments at JMA's Regional Instrument Center (RIC) Tsukuba. ・ The expert team and JMA experts from RIC Tsukuba conducted follow-up training on traceability for eight staff at INAM. ・The expert team proposed the introduction of field notes for daily observation and checkup notes for instrument maintenance, and conducted training on related usage at INAM and local stations. [Remarks] ・Indicator 1-3 was achieved. ・Through the meteorological instrument inspection training conducted by the expert team and JMA experts, technical transfer was completed at INAM Headquarters. INAM should conduct regular inspections for further implementation of effective technical transfer.
1-4. Meteorological instruments which ensure traceability of calibration are at least 80%.	・ The expert team transported standard barometers and thermometers calibrated at RIC Tsukuba and installed a constant-temperature tank in the INAM inspection room. ・ The expert team conducted training on the usage of barometer and thermometer standards. Through the training and the improvement of calibration facilities, traceability for these barometers and the thermometers of INAM Headquarters was established. ・ AWSs for precipitation, temperature and humidity were installed at three major airports, and a preliminary experiment for the future utilization of AWSs in Mozambique was implemented. [Remarks] ・Indicator 1-4 was mostly achieved. ・Traveling standards and equipment for calibration at INAM Headquarters have been improved, but instruments are not calibrated appropriately at certain local stations. INAM should hold regular training and OJT sessions for local staff.

In the area of weather forecasting and warnings, many forecasters gained a better understanding of the usage of ground observation, ARG, satellite and GPV data through presentations and exercises conducted by the expert team. More than three staff handling operational forecasting also improved their ability through forecast OJT on meteorological analysis and heavy-rain monitoring.

Table 6-2 Major Achievements of Output 2

Output 2 (Capacities in weather forecasting and warning at INAM are enhanced)	
Indicators	Major achievement
2-1. At least 3 staffs of INAM obtains ability to use ground observation, ARG, satellite and GPV data for forecasting.	▪ Presentations on weather forecasting areas such as synoptic meteorology, meteorological dynamics and numerical weather prediction were conducted. ▪ The expert team procured a PC and implemented the data storage necessary for heavy-rain event analysis and production of guidance, and introduced a forecast verification system. Forecast verification is conducted every week by forecasters, and the results are shared within the forecast department as weekly verification data. Monthly reports are also produced and published experimentally using weekly verification and stored data. ▪ The expert team provided forecasters with guidance on implementing post-analysis and warning evaluation for heavy-rain events and on producing extreme-event reports. Such content is very useful for accumulating and sharing the expertise and experience of forecasters. ▪ Presentations and exercises on forecast guidance were conducted several times, and forecasters worked to produce max./min. temperature guidance using stored meteorological and GPV data. ▪ Through exercises on satellite analysis and meteorological analysis with SATAID and JMA GPVs, forecasters gained a better understanding of heavy-rain monitoring with satellite and GPV data. ▪ Four INAM staff attended training on weather forecasting and warnings in Japan. The course promoted better understanding of JMA's advanced meteorological services. [Remarks] ▪ Indicator 2-1 was achieved. ▪ Through the presentations and exercises conducted by the expert team, INAM forecasters gained a better understanding of the usage of satellite and GPV data. In the future, more practical activities designed to leverage

	these achievements should be implemented toward capacity enhancement in daily weather forecasting at INAM.
2-2. At least 3 staffs, in charge for operational forecast, of INAM obtains ability to operate comprehensive weather forecasting.	・ The expert team conducted ongoing presentations and exercises on the utilization of satellite and GPV data and introduced a system for the storage of meteorological data on forecast verification, event analysis and other matters. Environments necessary for the enhancement of forecasting and warnings were established at INAM Headquarters. ・ Forecast OJT for weather forecasting and heavy rain monitoring was conducted from January to February 2017 and from February to March 2018. Forecast briefings involving the use of a large-screen display provided by JICA were highly evaluated by INAM forecasters, especially in relation to Cyclone Dineo in mid-February. INAM issued cyclone information and warnings promptly, earning high evaluations from disaster prevention authorities and others. ・ A weather guidance experiment using GPV data was implemented from February to March 2018. [Remarks] ・ Indicator 2-2 was mostly achieved. ・ Forecast OJT was very effective in leveraging the achievements of Output 1 for comprehensive operational weather forecasting. As capacity enhancement in weather forecasting and warnings depends on repetition in daily operation, event analysis and forecast verification, forecast OJT for heavy-rain events in particular and guidance experiments should be continued.

6. 2 Achievement of project purpose

The expert team conducted questionnaire and interview surveys on forecasts and warnings issued by INAM in cooperation with INAM, and obtained good responses that "forecasts and warnings has been improved in the past year" form disaster prevention authorities and media.

Table 6-3　Achievement of Project Purpose

Overall Goal (Capacities to respond the natural disasters are enhanced in Mozambique)	
Indicators	Major achievement
More than 80% of local authorities and other risk reduction and management highly recognize that INAM's services are timely and effective.	・ Surveys on user satisfaction and related needs regarding meteorological information issued by INAM were carried out with disaster prevention authorities and media operators. Around 80% of respondents reported improvement of INAM services over the past year. ・ The expert team paid visits to a disaster prevention authority (DNGRH), four TV companies and two newspaper companies, and conducted interview surveys on INAM weather forecasts and warnings. A variety of comments on possible INAM service improvement were provided, but responses were mostly favorable. [Remarks] ・ Close cooperation among INAM, disaster prevention authorities and media is essential for enhanced capacity in response to natural disasters. Regular communication among such parties is advised.
Project Purpose (INAM is capable to issue improved weather forecast and warnings by using quality-controlled meteorological data)	
Indicators	Major achievement
Improved contents of weather forecast and warnings	・ During a tropical cyclone that made landfall on Mozambique in February 2017, INAM issued cyclone information and warnings in a timely and effective manner, receiving high evaluation from disaster prevention authorities and a UN agency. [Remarks] ・ When extreme events occur, interview surveys on INAM weather forecasts and warnings should be actively conducted with users.

Chapter 7. Summary

The technical transfer on meteorological observation and forecast have mostly achieved the Project Purpose.

Some of the originally planned project activities had to be changed, because radars were not in operation, and also because GTS and the satellite system were not in operation.

However, INAM had carried out forecast work using materials obtained from the Internet. The Project provided technical transfer to suit INAM’s daily tasks, and C/Ps of INAM actively participated in the technical transfer activities. These efforts have promoted steady/effective progress, and issuance of early warnings for cyclones have shown more achievements than originally expected.

As is the case in many African countries in comparison to Meteorological Departments in Asian countries, the number of technical staff and their expertise in INAM are insufficient, facilities (e.g., network resources and equipment) and supporting infrastructure (e.g., stable commercial power supply and steady communications) are inadequate. On the other hand, INAM staff were very active in the learning process, and tried proactively and patiently to tackle any arising issues. There are two types of assistance that were received by INAM: 1) pre-packaged software/hardware installation and related training (e.g., the Synergy system) and 2) on-site technical transfer with experts through daily activities. (e.g., JICA Project.) The former enables prompt installation and usage of the latest techniques/systems, but the ready-made technical transfer is not adequate to enable INAM to resolve issues independently. The latter is favorable for steady technical transfer, but sometimes it is difficult to keep the C/P motivated during an extended period.

In either ways, there still remains significant gaps between the ideal level of technical expertise and the actual capacity/facilities of INAM, which will require a long time to fill. The following processes are necessary to efficiently enhance development of capacity and the technical expertise of INAM:

- Breaking down of steps/levels of technical expertise transfer, and achievement of each step in individual project phases
- Repetition of divided technical transfer activities by short-term experts than a long- term activity
- Activities targeting efficient utilization of the disseminated weather forecast/warnings, and efforts to meet user requirements.