Completion Report

Activity Schedule 34 of ROU 51172

Between Geoscience Australia and the Department of Foreign Affairs and Trade

For

COOPERATION ON THE DISASTER RISK MANAGEMENT PROGRAM IN INDONESIA

Volume 1 – Main Report

Edited by: Matthew Jakab and David Robinson
With contributions from: Ivan Busthomi, Phil Cummins, Thamrin Faizal, Hadi Ghasemi, Jonathan Griffin, Adi Kurniawan, Charlotte Morgan, Rikki Weber and Felix Yanuar

Contents

Acronyms

AS34	Activity Schedule 34
AHA	ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management
AIFDR	Australia-Indonesia Facility for Disaster Reduction
AITO	Australia-Indonesia Tectonics Observatory
ANU	The Australian National University
ARC	Either: (1) Australian Research Council or (2) Australian Red Cross
AS	Activity Schedule
AusAID	Australian Agency for International Development
AWI	Alfred Wegner Institute
BG	Badan Geologi
BIG	Badan Informasi Geospatial
BMKG	Badan Meterologi, Klimatologi dan Geofisika
BNPB	National Disaster Management Agency Badan National Penanggulangan Bencana
BoM	Bureau of Meteorology
BPBD	Provincial office of the National Disaster Management Agency Badan Penanggulangan Bencana Daerah
BPBD DKI Jakarta	Badan Penanggulangan Bencana Daerah Daerah Khusus Ibukota Jakarta
BPPT	The Agency for the Assessment and Application of Technology Badan Pengkajian dan Penerapan Teknologi
CDSP	Capacity Development Support Program/Partnership
CSO	Civil Society Organisation
DEM	Digital Elevation Model
DFAT	Department of Foreign Affairs and Trade
DMInnovation	Australian Government project in Indonesia to encourage the use of science and technology in Indonesian disaster management. Managed by GA and funded by DFAT
DM	Disaster Management
DMU	Disaster Management Unit
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DRU	Disaster Response Unit
DUPR	Ministry of Public Works and Housing
EOC	Emergency Operation Centre
EWS	Early Warning System
GA	Geoscience Australia
GAR	Global Assessment Report on Disaster Risk Reduction
GEM	Global Earthquake Model

GFDRR	World Bank Global Facility for Disaster Reduction and Recovery
GoA	Government of Australia
GoI	Government of Indonesia
GREAT	Graduate Research in Earthquakes and Active Tectonics (ITB program)
HOT	Humanitarian OpenStreetMap Team
HPC	High performance Computer (or Computing)
HU	Humanitarian Unit
IABI	Indonesian Association of Disaster Experts
InaSAFE	QGIS plugin for disaster managers
InaTEWS	Indonesian Tsunami Early Warning System
InaWARE	An advanced hazard early warning and monitoring system from PDC
IOM	International Organisation for Migration
ITB	Institut Teknologi Bandung
Jakarta DKI	Province of Jakarta Daerah Khusus Ibukota Jakarta
JATWC	Joint Australian Tsunami Warning Centre (Managed by GA and BOM)
JOSM	Java OpenStreetMap: Desktop editor for OSM
JSON	JavaScript Object Nation: standard data format that is easy for machines and humans to read and easy to distribute
Kelurahan	See below for Description of Relevant Area Classifications
KKP	Ministry of Marine and Fisheries
LIPI	Indonesian Institute of Sciences Lembaga Ilmu Pengetahuan Indonesia
NEHM	National Earthquake Hazard Map
NGO	Non-Government Organisation
NTT	Nusa Tenggara Timur (East Nusa Tenggara – Indonesian Province)
NU	Nahdlatul Ulama (faith based organisation with strong community programs)
MOU	Memorandum of Understanding
OSM	OpenStreetMap
PDC	Pacific Disaster Centre
PSHA	Probabilistic Seismic Hazard Assessment
PTHA	Probabilistic Tsunami Hazard Analysis
PU	Public Works Kementerian Pekerjaan Umum dan Perumahan Ralayat
Pusdalops	Emergency Operation centre at BNPB
PuSGeN	National Earthquake Research Centre Pusat Gempa Nasional
PVMBG	Centre for Volcanology and Geological Hazard Mitigation Pusat Volkanologi dan Mitigasi Bencana Geologi
QGIS	Open Source GIS program
R&V	AIFDR Risk and Vulnerability Unit – The Science Team

RW	See below for Description of Relevant Area Classifications
RT	See below for Description of Relevant Area Classifications
SD4CP	Scenario Development for Contingency Planning
Sendai	Sendai Framework for Disaster Risk Reduction
SK	An Indonesian legal/official tasking note
TATTs	Technical Assistance and Training Teams – a USAID funded program through Mercy Corps – Cardno US
TTX	Table Top Exercise
T&O	AIFDR Training and Outreach Unit
UGM	Universitas Gadjah Mada
UNDP	United Nations Development Program
UN ISDR	United Nations Office for Disaster Reduction
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
UoW	The University of Wollongong
UPT-BNPB	BNPB Regional Training and Logistics Training centres – also known as Regional Technical Implementation Units – AIFDR built the one in Padang
USGS	United States Geological Survey
VAAC	Volcanic Ash Advisory Centre
VISUS	Visual Inspecting for defining the Safety Upgrading Strategies – UNESCO program for safer schools
WB	World Bank

Executive Summary

Indonesia is one of the most disaster prone countries in the world due to its hazard profile and high population exposure. Despite its risk profile, disaster management has not traditionally been informed by best available information.

Since 2008, the Australian and Indonesian Governments have partnered to increase the use of science and technology in Indonesia to support decision making in disaster management. The partnership has focused on strengthening the evidence base for informed disaster management by improving:

- Hazard information for earthquake, tsunami, volcano and flood;
- Spatial data for exposure (population, building, roads and infrastructure); and
- Decision support tools such as InaSAFE that assist disaster managers to combine hazard and exposure data to inform disaster response and management.

Geoscience Australia (GA) has worked alongside Indonesian technical and disaster management agencies, universities, non-government organisations and the private sector to develop Indonesian capacity to manage disasters and institutionalise best-practices. Partnerships have facilitated science-to-policy and science-to-programming outcomes in disaster management that help people prepare for, respond to and recover from crises.

This completion report documents how the Australia-Indonesia science for disaster management program has increased the use of science and technology in Indonesian disaster management by developing new knowledge and enhancing capacity, both within the scientific community and within policy and decision makers. In doing so, tangible policies have been developed and implemented and practices have changed. The program has strengthened relationships between agencies within Indonesia and also between Indonesia and Australia in the areas of disaster management and science more broadly. New relationships manifest as distinct government-to-government collaborations and strong peer-to-peer links between scientists and policy makers.

Key Project Achievements

Preparation for and response to disaster through InaSAFE

Evidence based disaster management considers the impact of a hazard on the exposure. The DMInnovation project worked in partnership with the Indonesian National Disaster Management Agency (BNPB), the World Bank Global Framework for Disaster Risk Reduction (GFDRR) and Kartoza to develop a computational toolkit known as InaSAFE to assist disaster managers in preparing for and responding to disasters. This has led to significant increases in the use and sustainability of geospatial technologies for disaster management in Indonesia.

Key achievements include:

- InaSAFE has been used in Indonesia to inform national and sub-national contingency plans in East Java, East Nusa Tenggara (NTT), South Sulawesi and Maluku provinces. Based on its successfully use in Indonesia, InaSAFE is now being adopted globally, from Sub-Saharan Africa to Vietnam and the Pacific.

- Integration of InaSAFE with real-time hazard information for earthquake (ShakeMap), flood (just for Jakarta) and volcanic ash forecast data for near real-time impact assessments to inform disaster responses such as the Magnitude 6.5, 7 December 2016 Pidie Earthquake. BNPB now host the InaSAFE Realtime platform on assets gifted by the program.

- Two servers from the DMInnovation office were gifted to BNPB. A GeoNode (web-based application to share geospatial data) was installed on these servers and used for data sharing throughout the Mt Agung volcanic eruptions (October - December 2017). This was the first time, to our knowledge, that the Government of Indonesia (GoI) has utilised an internally hosted service to support the sharing of critical datasets between different GoI agencies during a disaster. The GeoNode is currently being used to store and distribute the hazard maps that were generated by technical partners throughout the Australian supported projects. Looking forward, this GeoNode will form an important asset for storing and sharing data for future disaster management exercises and evidence based response during unfolding disasters.

- Delivered training and supported the establishment of an Indonesian InaSAFE User Community with representation from a range of government organisations, NGOs and international agencies. It is anticipated that this user community will play a pivotal role in supporting the ongoing use of InaSAFE in Indonesia.

- Developed InaSAFE for Disaster Management Guidelines to guide disaster managers through the use of InaSAFE.

- InaSAFE has been used to inform the UNOCHA led Contingency Planning activity for a catastrophic earthquake in Jakarta, and the World Food Programme's support for the design and location of a network of humanitarian emergency supply hubs in Indonesia.

Supporting the use of spatial data in disaster management

Evidence based disaster management requires spatial data. In particular, understanding the distribution of people, buildings and infrastructure which may be impacted by a hazard event, is critical for both the preparedness and response phases of the disaster cycle. The DMInnovation project has embedded the use of exposure data and tools in disaster management by supporting an Indonesian community of users to generate and analyse their own spatial data. For example, the Indonesian public, including university students, have engaged in crowd-sourcing initiatives to assist in mapping the spatial footprint of the annual Jakarta floods.

Key achievements include:

- Supported the Humanitarian OpenStreetMap Team (HOT) to build an OSM community in Indonesia. The Indonesian branch of HOT (Perkumpulan OSM Indonesie) gained formal status as an independent association in Indonesia, which ensures it can receive funding from and work directly with Indonesian government into the future. Focus areas included:
  o New tools to support the capture and review of OSM data in the field;
  o Customisation of OSM resources for use Indonesia;
  o Training and events for a range of priority partners and universities;
  o Development and enhancement of training materials, manuals and curricula;
  o Support for participants in desktop training exercises;
  o International promotion of the activities; and
  o The integration of OSM, QGIS and InaSAFE training into Indonesian university curricula and publication of online OSM technical guides.

- Mapped over 15.2 million buildings and 579 000 km of road in OSM for Indonesia[1]. This data has been collected in priority areas informing BNPB contingency planning activities such as the Ambon DiREx 2016 Table Top exercise, an international disaster response planning and training exercise.

- Developed technological solutions to improve the efficiency of data management systems. The DMInnovation project invested in the OSM Tasking Manager to coordinate efficient spatial data collection and reduce redundancy. This has been used in Indonesia to directly support disaster responses such as the 15 December 2017 M6.5 Taskimalaya Earthquake. As well as by BNPB to manage mapathons in priority districts earmarked for comprehensive disaster management. DMInnovation also designed and invested in the OSM core functionality including development of the Tasking Manager. This tasking manager has now been used globally to facilitate 1.25 million mapping projects, informing decision making and response for Ebola management in Africa, the 2013 Super Typhoon Yolanda in Philippines and the Magnitude 7.8 25 April 2015 Nepal Earthquake. This is an example of a tool developed by DMInnovation that has changed the workflows of millions of projects around the globe.

- Worked with the University of Wollongong to develop base level digital maps and a system for real-time flood mapping for Jakarta that is based on Twitter analytics. This system is now operational and is informing disaster response by the Jakarta provincial level disaster management agency (BPBD Jakarta DKI) every wet season. Furthermore, the system is being replicated across other Indonesian cities under a USAID funded project.

- The activity successfully prototyped new low cost, smart sensors using sonar sensing of water levels, which were connected to the PetaJakarta database. This pilot project tested the sensors in 4 locations and demonstrated that this inexpensive flood sensor technology could be deployed in a practical setting to monitor river heights in real-time.

- Created curriculum and training materials, in Bahasa Indonesia and English, including:
  - Guidelines for running a Mapathon Event (Indonesian);
  - Guidelines for OSM Data Collection (English and in Indonesian); and
  - OSM for Individuals with Disabilities (Indonesian).

Tsunami Hazard

Indonesia is one of the most tsunami prone countries in the world. Through this program Indonesia's capacity to develop a scientific understanding of tsunami hazard to inform disaster management and help people prepare for, respond to and recover from tsunami has increased.

Key achievements include:

- Produced the first National Tsunami Hazard Map based on world's best practise probabilistic methods. This map has been, and will continue to be, used to prioritise tsunami mitigation and research investment across Indonesia.

- Strengthened coverage of the Indonesian tsunami warning system in eastern Indonesia to align with the robustness of the western Indonesia. This was achieved by increasing the number of earthquake sources in the InaTEWS scenario database from 4,580 to 17,317.

- Strengthened the Indonesian tsunami warning system by streamlining workflows to generate more robust warnings across all of Indonesia, contributing to the safety of millions of Indonesians living on or near the coast.

- Developed capability within the Indonesian Geological Agency – Badan Geologi (BG) to produce local scale tsunami inundation maps. To date 17 local scale hazard maps have been generated.

---

[1] These values are as reported by HOT in May 2018.

- Fostered collaboration between tsunami scientists at BG and the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) through combined training workshops and leading discussions on applications of inundation modelling to the InaTEWS. Prior to the DMInnovation project BG and BMKG had not worked together on tsunami inundation. It is expected that this new collaboration will continue in the future.
- Facilitated the establishment of a relationship between BG and Badan Informasi Geospatial (BIG) which means BG can access essential digital elevation data required for tsunami inundation modelling now and into the future.

Earthquake Hazard

Indonesia has experienced over 2000 earthquakes with magnitude greater than 5 since 1960 making it one of the most seismically active countries in the world. The DMInnovation program has enhanced Indonesia's capacity to develop scientific evidence on earthquake hazard to inform disaster management and prepare for, respond to and recover from earthquakes.

Key achievements include:

- Developed and strengthened a capability across multiple Indonesian Government Agencies and Universities to undertake sophisticated earthquake hazard modelling based on international best practice. This included training in two earthquake software packages: the EQRM and OpenQuake.
- Supported Indonesian agencies to development of the National Earthquake Hazard Map (NEHM) launched on 4 September 2017. The map was developed with input from more than ten Indonesian agencies and universities working under a governance structure facilitated through the DMInnovation project. The new hazard map indicates a higher than previously understood earthquake hazard in some areas of Indonesia including the highly populated region of northern Java.
- Data from the newly developed Indonesian NEHM has been shared with the Global Earthquake Model (GEM) Foundation, enabling inclusion of the map in the earthquake hazard global mosaic that GEM will make available to earthquake hazard researchers worldwide. By sharing this data, Indonesia is allowing foreign experts and researchers to quality assure the work and potentially contribute to further advances. This is the first time the GoI has opened this data internationally representing a significant step towards its willingness to collaborate internationally.
- The governance structure implemented for the NEHM has been adopted in the design of the new National Earthquake Research Centre (PuSGeN). A formal proposal for the establishment of PuSGeN has been submitted to the minister for the Department of Public Works (PU). Negotiations for the formalisation of PuSGeN are ongoing.
- Trained BMKG in the use of the ShakeMap and assisted them to establish an operational real-time system which produces estimates of ground shaking within minutes for all significant Indonesian earthquakes. Through the testing of ShakeMap 4.0 at BMKG in 2018, software errors were identified and reported to United States Geological Survey (USGS) team, who have formally acknowledged BMKG's contribution. This has assisted to raise BMKG's international profile.
- Fostered advances in knowledge and capability within all five fields of earthquake science that is directly relevant to the NEHM. In particular, advances in BMKG's ability to store and learn from strong ground motion recordings will, with time, lead to significant improvements in the way Indonesia models and consequently understand its earthquake hazard.
- Supported BG to produce new provincial scale earthquake hazard maps for all Indonesian provinces.

Volcano Hazard

At any point in time there can be multiple volcanos across the Indonesian archipelago that are either erupting or on a high level of alert for a pending eruption. In the immediate vicinity of the volcano, people are displaced, sometimes for years or decades creating challenges for society. Moreover, eruption impacts extend beyond the immediate vicinity of the volcano creating additional challenges for disaster managers. Volcanic ash impacts the airline industry, and when it falls to the ground it disrupts the lives and livelihoods of people distal to the volcano. Our program has focussed on increasing the understanding of ash fall as it is the volcanic hazard with the widest reach and greatest economic impact.

Key achievements include:

- Supported BG to develop ash modelling skills for single scenario eruption models and probabilistic eruption models for contingency planning.
- Developed a volcanic ash fall forecasting capability at BG that is now deployed in real-time following a volcanic eruption and/or raised alert. This step delivers maps of ash depth in real-time.
- Developed the InaSAFE Volcanic Ash Realtime system and trained BG in the use of this system to enable reporting on potential impacts to population, infrastructure and crops in real-time. This system was utilised heavily during the management of the Mt Agung eruptive period (October – December 2017) and has also been utilised during eruptions of Merapi and Sinabung.
- Built stronger connections between BG and the Australian Bureau of Meteorology (BOM). This facilitates BOM's access to BG field observations for informing volcanic ash advisories to the international aviation industry. The relationship also facilitates BG to access high quality wind data for use in volcanic-ash forecasting.
- Generated probabilistic ash fall maps for 7 Indonesian volcanos.

Investing in Tertiary Education for Active Tectonics

Ensuring future disaster management is informed by credible science requires a strong tertiary education sector that can develop the skills of a new generation of technical experts. The DMInnovation program have invested in the Indonesian tertiary sector creating new programs to educate qualified hazard experts and strengthen links between Indonesian and Australian universities.

Key achievements include:

- Worked with the Institute of Technology Bandung (ITB) to create a multidisciplinary centre for earthquakes and active tectonics research - Graduate Research School for Earthquake and Active Tectonics (GREAT). The school has graduated four PhD and 30 Masters students, many of whom have returned to Indonesian technical agencies where they will continue to inform government programs for decades.
- Strengthened relationships between ITB and the Australian National University (ANU), with co-supervision of graduate students and the signing of a joint Master's degree program that allows students to complete a two-university authenticated master degree with one year at each university.
- Supported five masters and two PhD students to study at the ANU. Four of these students have returned to Indonesia and are now working in the Indonesian Government. Furthermore, there is a successful New Colombo Plan proposal that will see two cohorts of ANU students travel to Indonesia to learn from ITB's programs.
- Targeted graduate research projects that feed results directly into the national earthquake mapping program.

- New research from the university sector is enhancing the understanding of earthquake hazard in Indonesia and is, in many cases, directly informing the development of the NEHM. Examples include:
  - Provision of instruments for the Australia-Indonesia Tectonics Observatory (AITO), a pool of geophysical instruments, co-funded by ANU's Major Equipment Committee, were supplied to Indonesia. The seismometers (recorders for collecting earthquake data) and GPS receivers (for measuring crustal strain) will be used in collaborative ANU-ITB studies of active tectonics in Indonesia over the next 10 years.

**Geoscience Australia (GA) Staff Deployment to Indonesia**

GA completed corporate and individual preparations to deploy two staff members to Jakarta – the Senior Spatial Data Analyst who arrived 12 September 2014 and the Chief Scientist who arrived on 14 November 2014. This involved the creation of new corporate guidelines and operating procedures to support deployed officers (a GA first).

Key achievements include:

- Corporate preparations:
  - Familiarisation with and endorsement of the Whole of Government (WOG) Overseas Conditions of Service 2012;
  - Familiarisation with and endorsement of the Deployment Support Services provided by HKL to GA deployees; and
  - New GA contract, HR and finance procedures to ensure that GA could support deployees in Jakarta.
- Deployed GA staff took on a number of activities including:
  - Management of five locally engaged technical experts;
  - Management of DFAT funded grants and contracts to implementing partners including Kartoza, Humanitarian Open Street Map Team (HOT), ANU, ITB, Alfred Wegner Institute, and the University of Wollongong;
  - Management of and replacement of high-performance computing infrastructure;
  - Preparation for increased office management responsibility as the Menara Thamrin Office was converted from a Facility Office run by DFAT to a Project Office without direct DFAT management. This included drafting and negotiating a Service Order with logistics company HKL on behalf of DFAT; and
  - Planning for a reduced overall budget to the DM sector in Indonesia during the changeover to DMInnovation.

1 Introduction

Indonesia is one of the most disaster prone countries in the world due to its hazard profile and high population exposure. Despite this, many disaster risk management decisions in Indonesia are not informed by adequate, or best available, information. Decisions have historically been made with inadequate information about the severity and recurrence of hazards and without appropriate spatial data and analysis that allow disaster managers to determine the spatial distribution of consequences. This increases the likelihood that response preparedness and mitigation activities focus on the wrong areas and hazards. The collaboration has increased the use of science and technology in disaster management and improve the evidence based used to inform key disaster management decisions and policies. DMInnovation achieved this through the following logic:
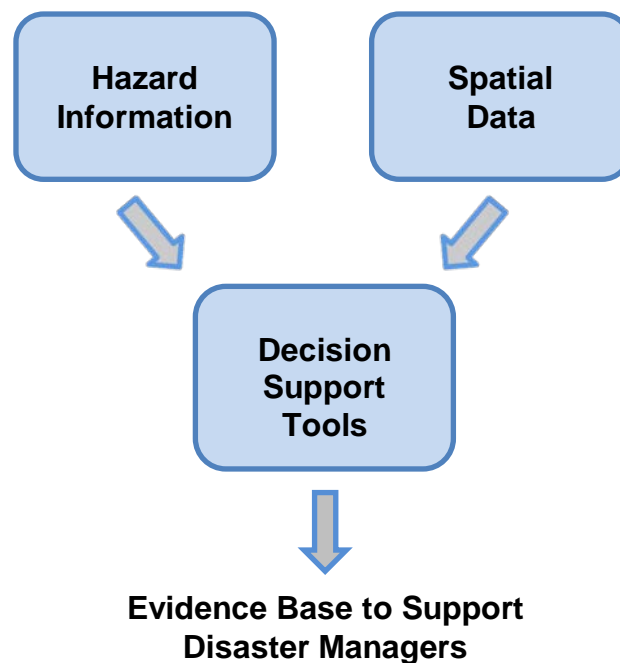
Approach

Management

Management of the science partnership has fallen under three distinct phases:

- Phase 1 - July 2008 to June 2014: Risk and Vulnerability Section of the Australia-Indonesia Facility for Disaster Reduction, or AIFDR;
- Phase 2 - July 2014 to December 2015: Risk and Vulnerability Section during the transition period of AIFDR;
- Phase 3 - January 2016 – June 2018: DMInnovation or Disaster Management Innovation following the formal closure of AIFDR.

This completion report covers Phases 2 and 3 (i.e. 1 July 2014 until 30 June 2018) during which period GA assumed direct responsibility for the leadership and direction of the collaboration through

Activity Schedule 34 (AS34) of ROU51172. Prior to this, the project was led by GA officers seconded to AusAID and did not fall under direct GA management. Nevertheless, it is important to note that the activities of Phases 2 and 3 built on a strong foundation that was established during Phase 1. Consequently, many of the achievements identified in this completion report can be traced back to activities and relationships that began during Phase 1.

Changes in Activity Classification and Implications on Reporting Style

The transition from Phase 2 to Phase 3 (i.e. the creation of DMInnovation) also involved changes to the formal collaboration agreement between the Indonesian and Australian Governments which in-turn led to a re-packaging of activities under new program and activity level classifications as defined below. For the purpose of clarity, and to support ongoing DFAT reporting, this completion report documents all achievements against the program and activity level classifications that were developed at the time DMInnovation was created (i.e. the beginning of Phase 3). These are summarised in the following table.

Table: DMInnovation Program and Activity Descriptions as defined for Phase 3

Program	Activity
Program 1: Embed the use of exposure information management and tools for Disaster Management	• *Activity 1.1:* Enhance the real time information available during flooding in Jakarta (Peta Jakarta) • *Activity 1.2:* Disaster Management Innovation through Open Geospatial Data
Program 2: Enhance the ability of Indonesia to prepare and respond to disaster through InaSAFE	• *Activity 2.1:* InaSAFE Enhancement and Institutionalisation within BNPB (Kartoza) • *Activity 2.2:* Policy development and technical support of selected BNPB activities to facilitate the institutionalisation of geospatial technologies in Disaster Management
Program 3: High quality research training in earthquake, active tectonics and tsunami science in Indonesian	• *Activity 3.1:* Geodisaster Research and Education to support DRR in Indonesia and create a sustainable GREAT Program at ITB • *Activity 3.2:* Help strengthen the teaching and research programs of GREAT and ensure that it is pitching at the highest international
Program 4: Capability within Indonesia to produce Hazard Map/Information that informs disaster management.	• *Activity 4.1:* Updating national earthquake hazard map to inform building codes, disaster management and other relevant policies in Indonesia. • *Activity 4.2:* Support to develop capability within Indonesia to produce tsunami inundation maps • *Activity 4.3:* AWI - Technical Support to develop capability within Indonesia to extend the tsunami warning system • *Activity 4.4:* Support to develop GOI Capability to generate volcanic ash fall map
Program 5: Advance capability of GOI to store and learn from earthquake record and information to support disaster management.	• *Activity 5.1:* Strengthened capability within GOI to store and learn from earthquake recordings and other data such as post-event damage data

Modalities adopted by Geoscience Australia

Three modalities were adopted by GA throughout implementation of AS34:

1. Pre-deployment of GA in-country officers - July 2014 to October 2014
    -   One GA officer was based at the Menara Thamrin office in Jakarta under an extended short-term-mission. Remaining GA officers (up to four full-time-equivalents) supported the program from Canberra taking short-term missions as needed.
    -   Locally engaged, Indonesian contractors working from the Menara Thamrin office in Jakarta.
    -   NGOs, universities and private sector organisations that are directly engaged by DFAT and managed in partnership with GA.

2. Deployment of GA in-country officers - October 2014 to June 2017
    -   Two GA officers deployed under the Whole of Government Posting Arrangements and working from the Menara Thamrin Office in Jakarta.
    -   Two full-time-equivalents of GA technical specialists who partnered remotely and took short-term missions as needed.
    -   Locally engaged, Indonesian contractors working from the Menara Thamrin office in Jakarta.
    -   NGOs, universities and private sector organisations that are directly engaged by DFAT and managed in partnership with GA.

3. Post Deployment of GA in-country officers - July 2017 to June 2018
    -   All GA officers based in Canberra (3.5 full-time-equivalents) partnering remotely and taking short-term missions as needed.
    -   Locally engaged, Indonesian contractors working from the Menara Thamrin office in Jakarta.
    -   NGOs, universities and private sector organisations that are directly engaged by DFAT and managed in partnership with GA.

2 Analysis of Program Implementation

2.1 Relevance

Indonesia, due to its tectonic position, can experience large-scale disasters caused by earthquake, tsunami or volcanic eruptions. Given the population of Indonesia these events can be catastrophic. The GA led activities promoted the use of credible science in planning and mitigation against these types of disaster through targeted collaborations and capacity building workshops. In doing so, GA has positively impacted on outcomes of the Australian Development Program by strengthening Indonesia's capacity to respond to a large-scale humanitarian crisis through increasing the use of evidence in disaster management decisions. Moreover, GA has supported Australia's national interest by investing in new policies, procedures and support systems, to reduce the impact of disasters and contribute to sustainable growth and poverty reduction in Indonesia. These are key components of the Australian Government's Aid Investment Plan. The following paragraphs demonstrate through examples how the program outcomes have been highly relevant to the GoI in reducing community risk for each of the key hazards; earthquake, volcano and tsunami.

Earthquake hazard

One way to reduce fatalities from earthquakes that has proven effective is to improve construction practices through the development of a building code that reliably addresses the level of hazard. The new earthquake hazard map will contribute directly to new building codes for buildings, and infrastructure such as road, power generation facilities, airports and ports. This work is currently being undertaken by the same community that DMInnovation have up-skilled and is being coordinated under the governance structures of PuSGeN as designed in this program. Furthermore, the existence of a national seismic hazard map is the foundation for future work to improve Indonesia's understanding of seismic hazard

The InaSAFE Realtime earthquake system provides a forecast of impact directly into BNPB's operation centre within minutes of an earthquake. This means reliable evidence based information on the scale of the disaster is delivered to decision makers faster when compared to traditional information gathering techniques that can take hours or days in remote communities. This information, delivered through InaSAFE Realtime, is relevant to the Indonesian disaster management community who used the system during their response to the Magnitude 6.5, 7 December 2016 Pidie Earthquake.

Volcano hazard

Indonesia has over 130 active volcanoes. Past experience has proven that monitoring and issuing warnings of eruptions can save lives. The next step for Indonesia is planning for the impacts on livelihoods from eruptions. The volcanic hazard with the biggest spatio-temporal impact is that of volcanic ash fall. The DMInnovation volcanic ash-fall project has created new capacity within Indonesia to ascertain and forecast the impact of ash-fall in real-time to understand the impact on airports, agriculture and water supply as well as population. Badan Geologi is delivering this information through InaSAFE Realtime which is directly informing the planning and response activities of BNPB.

Tsunami hazard

Indonesia has experienced large and devastating tsunami in the past and has a significant coastline exposed. Tsunami warning times in Indonesia can be as little as 20 minutes. Thus, it is important to have both an up-to-date warning system which is easy to use, and local scale hazard maps that facilitate evidence based contingency planning. The focus of GA's two pronged approach – updating the warning system and enhancing capability for inundation modelling – has ensured that Indonesia is better placed than ever before to manage the ever present risk of tsunami impacting Indonesian coastal communities. Tsunami contingency and evacuation plans are now routinely based on evidence from tsunami hazard maps and tsunami warnings in eastern Indonesia are more accurate with less false warnings.

Underpinning all hazard and risk products is spatial data. Spatial data and technologies, including understanding the spatial footprints of hazards, are highly relevant for GoI to implement international initiatives and develop national Disaster Risk Reduction (DRR) policies. In 2015, Indonesia ratified the Sendai Framework for Disaster Risk Reduction (Sendai) 2015-2030 as a platform for disaster management. In order to implement Sendai, Indonesia must address the activity of "Understanding Disaster Risk" by developing disaster risk information for inclusion in the policy development process. This requires geospatial information technology to generate and disseminate information, including hazard maps and risk assessments to decision makers, the public and communities at risk. GA supported Indonesia to meet these requirements by incorporating spatial data and InaSAFE throughout the disaster management cycle. In addition, GA built capacity within Indonesia to collect and store spatial data by developing their spatial technologies including OSM and InaSAFE.

2.2 Sustainability, Ongoing Risks and Constraints

A key component of the Phase 3 work period under DMInnovation has been ensuring the sustainability of all GoA interventions under the science for disaster management collaboration.

The single most important factor influencing the ongoing risk to sustainability is turnover of staff within GoI partner agencies. This turnover is often due to internal agency restructuring and appointment of trained GoI staff to new roles. There were many instances across the 10-year collaboration where staff transfers impacted ongoing activities requiring GA to assist in reskilling new staff. For example, an agency reshuffle in 2016 at BG led to the reassignment of critical volcano staff to the landslide division without consideration of peer-to-peer handover or training of new staff coming into the volcano division. This, combined with substantial changes to the modelling code from the developers, meant that Activity 4.4 had to be redesigned by GA to rectify the loss of capability in BG by training a larger group of staff. Similar issues were encountered with BNPB reassigning InaSAFE participants (Activity 2.1) to new roles, which impacted the implementation and sustainability of InaSAFE within BNPB. In the future it will be the responsibility of GoI agencies to maintain their own expertise and plan suitable handover and cross training of staff to ensure that key skills and knowledge is maintained in appropriate areas.

Although there was consistent and clear communication that the DMInnovation project was ending in June 2018 and that there was no follow on project, the idea persisted with several stakeholders that the project would not end or that something would replace it. This was constantly managed by GA officers who communicated frequently with partners to manage these expectations. It is likely that this impacted sustainability on some activities (particularly Activity 2.1) as ongoing belief persisted that the work would be continued and further support could be accessed from GA into the future. Some of this

confusion may have been due to the long history of collaboration and historical observations from when AIFDR closed and DMInnovation was launched. Furthermore, in at least one instance a partner was left with the impression that their ideas would be adopted following discussions with the DFAT engaged Sector Analysis Team. This may not have been a fault attributable to the Sector Analysis process, but this incorrect impression was created nonetheless.

The hazard components of the DMInnovation project were by far the most advanced in terms of sustainability, since there has been a long running history of technical engagement across multiple organisations and at multiple levels. In regards to earthquake hazard assessment, release of the new National Earthquake Hazard Map enabled the agencies involved to look for ways to continue working together (e.g. through the establishment of PuSGeN). This capacity within Indonesia is considered sustainable by both GoI and GoA, in terms of numbers of staff that are capable of performing earthquake hazard assessments as well as the access to software, high performance computing (through equipment gifted to PuSGeN). Collaboration within Indonesia and in the international community through GEM will also serve to support this capability.

Significant effort was put into the development of InaSAFE and the capture of appropriate spatial data, both through the HOT grant and the hazards components of the DMInnovation project. However, technical engagement with the end user BNPB only gained meaningful traction in 2017. Despite a lower level of maturity for this engagement, the program established packages of work specifically designed to accelerate the capacity building in BNPB, and to get staff trained to a level of sustainable proficiency. This was complemented by the gifting of assets and the support to host InaSAFE real-time and a GeoNode. In the latter part of 2017 there was more "buy-in" from key BNPB staff on the importance of InaSAFE and their wanting to adopt it for their day to day business. For detailed information on the risks and constraints of InaSAFE within BNPB please refer to Volume 2.

2.2.1 Program 1: Exposure information management and tools

Program 1 had two components:

- Activity 1.1 designed to enhance the real time information available during flooding in Jakarta (Peta Jakarta)
- Activity 1.2: designed to support Disaster Management Innovation through Open Geospatial Data

Activity 1.1:

Peta Jakarta was implemented by DMinnovation grantee the University of Wollongong (UoW). The project involved the analysis of Twitter information to map Jakarta flood footprints in real-time from crowd sourced data. This project implemented a real time flood mapping capability in the Jakarta provincial emergency management centre that continues today and is considered sustainable. Moreover, the USAID now has an active project to replicate this work in other major Indonesia cities including Bandung and Surabaya. This replication to further cities will create a network of capable GoI employees across Indonesia who will continue to maintain the technology and skill base to keep the functionalaity sustainable.

Activity 1.2:

The following key initiatives were successfully implemented in Indonesia:

- Building capacity within BNPB to ensure the national disaster management agency has a critical mass of trained staff in the use of geospatial technologies.

- Establishment of an independent OSM Association in Indonesia (Perkumpulan OSM Indonesia) which will continue to support OSM mapping projects into the future and can receive funding directly from GoI agencies.
- Collaboration with BIG and the adoption of OSM as a national standard for geospatial data to support and endorse OSM use across GoI.
- Creation of YouthMappers Chapters in Universities across Indonesia to continue to educate the next generation of OSM capable graduates.

The achievements of these initiatives and the integration of them within the disaster management sector suggest a high likelihood of ongoing and sustainable use of spatial data in the Indonesian disaster management. In particular:

- The use and storage of OSM data in Indonesia has made significant progress towards sustainability. BNPB are familiar with this data and its utility. Several staff in BNPB are trained in the capture and use of this data as well as having the skills to train others. For example, BNPB have begun hosting their own mapathons without DMInnovation support (for example, the mapathon held in Bali for Mt Agung). GA and locally engaged DMInnovation staff promoted the benefits and limitations of OSM data, including the integration of OSM data into BIG's geospatial data workflows.
- The establishment of Perkumpulan OSM Indonesia that can be contracted or funded directly means that GoI has a clear pathway for accessing data collection and analysis support as needed. Moreover, this organisation has demonstrated its capacity to source funding from other key donors in Indonesia such as USAID.

2.2.2 Program 2: InaSAFE use and enhancement

This program focussed on the enhancement and institutionalisation of InaSAFE in BNPB (Activity 2.1) which was facilitated by policy development and support of selected BNPB disaster management activities (Activity 2.2). To understand the potential sustainability of InaSAFE in Indonesia it is useful to separate InaSAFE into its two major use areas:

- **InaSAFE Desktop** – is the version of InaSAFE installed locally on individual computers and used interactively by an individual user. There is now a significant international InaSAFE Desktop user community that collectively, and through newly created Governance arrangements, continue to support the ongoing software development and use of InaSAFE globally. InaSAFE Desktop sustainability in Indonesia therefore comes down to its continued use, maintaining its currency (i.e. using the latest version) and its dependency on the QGIS platform.
- **InaSAFE Realtime** – the real-time version of InaSAFE is deployed only in Indonesia, on IT infrastructure that sits within BNPB. InaSAFE Realtime can only be used sustainably into the future in Indonesia if BNPB takes the lead on investing in ongoing development and maintenance. This will require direct investment in software upgrades to keep pace with operating system updates and other external dependencies such as QGIS. That is to say, Indonesia will not be able to rely on an international community to undertake this investment as they are the only user of InaSAFE Realtime. Considerable effort has been undertaken by GA and DMInnovation locally engaged staff to support BNPB to take on this responsibility. Nevertheless, it will only become apparent over the coming 1-2 years how well BNPB are positioned to discharge this responsibility. This component of the program is at the highest risk of not being sustained in Indonesia.[2]

---

[2] As this report was going to press InaSAFE Realtime worked successfully and was used by BNPB to inform the initial responses to the Magnitude 6.9 5 August 2018 and the Magnitude 6.4 29 July 2018 earthquakes in Lombok. These were the first two significant Indonesian earthquake following the closure of DMInnovation.

Some of the key activities that GA has worked on to support BNPB to adopt InaSAFE sustainably include but are not limited to:

- Institutionalisation of InaSAFE in Indonesia.
- Capacity building within BNPB including the hosting and maintenance of InaSAFE Realtime.
- Engagement with an Indonesian User Community.
- Development of an International Governance structure to manage future InaSAFE developments and releases.

Some of the key issues that GA encountered when working with BNPB include:

- BNPB staff reliance on GA and DMInnovation staff to manage issues with the BNPB InaSAFE Realtime server and find solutions. The sustainable use of InaSAFE Realtime in Indonesia will depend on BNPB proactively identifying and fixing problems in the future.
- Difficulties encountered by program management in Canberra engaging with and getting feedback from BNPB staff.
- BNPB sought technical support from implementation partners (HOT and Kartoza) outside the scope of the agreed program. For example, support for an OSM GeoNode and OSM tile server. There were times when these direct requests distracted the focus of implementation partners from our work plan. Despite this, BNPB's willingness to seek assistance directly from HOT and Kartoza should be viewed as a positive outcome of DMInnovation's work to assist these implementing partners to build their credibility. BNPB's willingness to seek assistance bodes well for the ongoing maintenance and sustainability InaSAFE provided they are prepared to back these requests with funding.

It is likely that there will no external funding to directly support InaSAFE maintenance in Indonesia in the future. Therefore, without BNPB investment in infrastructure and resources, InaSAFE may prove difficult to sustain in Indonesia. In particular it is unclear whether BNBP:

- is prepared to, and able to invest in infrastructure to host InaSAFE Realtime and GeoNode services and establish adequate backup procedures to ensure reliability of these services.
- staff understand the requirements of hosting and maintaining InaSAFE Realtime platforms, despite capacity building training.
- are able to fully resource the maintenance and development of InaSAFE to align operational Desktop and Realtime InaSAFE versions with future InaSAFE and dependency (e.g. QGIS) software upgrades.

It is hoped that the establishment of an Indonesian InaSAFE User Community will help to maintain the InaSAFE skills and influence BNPB to continue to invest in InaSAFE in Indonesia. This community is still in its infancy. However, there are a number of key individuals and organisations that are engaging within this community and GA believes it has strong potential to gain traction and continue sustainably.

InaSAFE global governance discussions have proceeded well and a new international governance structure is expected to be endorsed in the near future. Unfortunately, however, BNPB are yet to engage and accept a guaranteed seat on the Steering Committee. Whilst, this is not essential, engaging in the international steerage of InaSAFE will enhance BNPB's:

- influence over future developments.
- access to international experts to help solve issues.
- access to support for InaSAFE in Indonesia.

- status as one of the founding members of InaSAFE.

2.2.3 Program 3: Research training in active tectonics

This program supported the development of a high quality graduate level research training capability in Indonesia for earthquakes and active tectonics. The program was delivered through separate grants to ITB (Activity 3.1) and ANU (Activity 3.2) to support and encourage collaboration and knowledge sharing between the two universities. Over half of the 40 Masters and 8 PhD students supported by this project to study earthquakes and active tectonics have moved on to positions in GoI technical agencies and academia, where they will continue to influence government policy and academic research and education in ways that support earthquake disaster mitigation.

Through this Program ITB has been firmly established as a provider of earthquake research services and products to GoI technical agencies, such as geodetic and geological studies of active faults and seismological studies of earth structure and earthquake source properties.

ANU collaboration with ITB in earthquake research and education is likely to continue for many years through the established of a split-site Master's degree program as well as through the strong relations established between ANU and ITB faculty's that are expected to result in collaborative research proposals submitted to both Australian and Indonesian funding agencies. It is important to note, however, that despite the willingness on both sides, the ability to sustain ongoing collaborations will depend on the ability of ANU and ITB to source funding through competitive grant processes, the outcome of which is by no means guaranteed.

Establishment of the Australian-Indonesian Tectonics Observatory (AITO) provides a pool of geophysical instrumentation that will attract support for Australian-Indonesian collaborative research projects not only from GoA and GoI sources, but also from overseas research institutions. Thereby widening the network of collaborative research opportunities in Indonesian earthquake science. For example, the AITO is already slated to provide instruments for a Cambridge University led project in earthquake hazard in Kalimantan and Sulawesi, and has been proposed for use in a project led by the United States Geological Survey to study the Agung-Batur volcanic complex in Bali.

2.2.4 Program 4: Building hazard assessment capability

This program was designed to dvelop capability within Indonesia to prodiuce hazard maps and information to inform disaster managent.

Earthquake hazard (Activity 4.1)

The 2017 Indonesian earthquake hazard map generated will underpin the seismic loading provisions in Indonesian building codes. Upon implementation, these codes will result in more seismically resilient construction practises for large buildings and infrastructure reducing community risk.

This Activity has resulted in a new culture of collaboration among GoI technical agencies and academia that is being formalised in the establishment of an Indonesian National Centre for Earthquake Studies (Pusat Studi Gempabumi Nasional, aka PuSGeN), which will continue to serve as a platform for multi-agency collaboration in research to support earthquake hazard mitigation.

The Activity has resulted in the training of many staff from GoI technical agencies in the principles and practice of earthquake hazard and risk assessment. These skills will continue to be used in the

development of improved national earthquake hazard maps as well as in more detailed studies of Indonesian earthquake hazard and risk at provincial and city scale.

Lasting relations between PuSGeN agencies and the GEM foundation, which develops international best practice earthquake hazard and risk tools and models, have been established by this activity. This engagement is expected to endure as the Indonesian Ministry for Public Works and Housing currently in the process of negotiating GEM membership for Indonesia. Indonesian GEM membership will provide PuSGeN with world-class expertise in earthquake hazard and risk assessment that will support GoI disaster mitigation.

Tsunami hazard (Activity 4.2)

The tsunami inundation hazard mapping capability that has been built within BG is considered sustainable.

- There are a number of suitably qualified staff to undertake tsunami modelling and interpret the results. One of these BG staff played a leading role in delivering the final tsunami inundation training workshop demonstrating that BG now have the capability to teach their own staff and other agencies how to undertake tsunami inundation modelling.

- There is now an established workflow in place for accessing elevation data from BIG without GA or BNPB involvement. However, accessing data that is of suitable quality for all locations in Indonesia remains problematic. For example areas of Kalimantan and West Papua, where the GoI does not currently hold suitable data.

- Sustainable access to computing facilities has been identified by BG as a potential issue moving forward. BG is currently working on two potential solutions to this problem:

  o Improved access to the high performance computing resources established at PuSGeN

  o Establishing their own small high performance computer at BG.

  BG's ownership of this issue and their action in finding a resolution provides confidence that they are well positioned to establish and sustainably manage the right solution for them moving forward.

Tsunami warning system (Activity 4.3)

Updates to the tsunami warning system are considered sustainable.

- There are suitably qualified BMKG staff to run the system and maintain the system as well as update the tsunami sources in the system if required.

- Both the centre in BMKG and the regional BMKG office in Bali have received training in all aspects of the system.

- BMKG is confident in running the enhanced tsunami warning system and are now focussing on increasing ties with BG so they have access to expert information on tsunami inundation to complement their system.

Volcano ash fall mapping (Activity 4.4)

This Activity was re-scoped in early 2016 as a result of key staffing changes at BG and changes in the Fall3D code made by the developers. At the time, this posed a setback to the sustainability of this Activity. To strengthen this activity, training was refocussed on a larger group of staff with a specific emphasis on the real-time forecasting capability. There are now 2 staff members that are proficient in modelling of real-time ash fall from eruptions and integrating the results with the InaSAFE Volcanic Ash Realtime system, with another 4 familiar with the process. This extra depth (i.e. 6 staff) provides BG with more options during the next round of staff transfers.

BG demonstrated that they can use the InaSAFE Realtime system operationally, during the recent eruptive phase of Mt Agung (October – December 2017) and the eruption of Mt Sinabung (February 2018). Further steps were taken by GA to increase the sustainability of this capability, by inviting the Fall3D code developers to lead the final training workshop, facilitating the deepening of an ongoing relationship between them and BG. BG can now ask the developers for assistance and advice directly.

There is however is concern over data access, this capabilitymay not be sustainable without access to high quality meteorological data, which has to date been accessed from BoM. Future arrangements for access to this data will need to be negotiated directly between BG and BoM without GA involvement.

2.2.5 Program 5: Strengthened capability to store and use earthquake data

This program was designed to advance the capability within GoI to store and learn from earthquake data and information to support disaster managent. Under this Program, two business-critical systems were established at BMKG:

1. *Seiscomp3 system*: These updates have enabled BMKG to retrieve, process, and archive strong-motion records in both real-time as well as manual modes. This tool has also been used extensively to generate earthquake reports following significant earthquakes in Indonesia through integration with the ShakeMap system.
2. *Earthquake ShakeMap system*: This system has enabled BMKG to produce near-real time maps of ground-motion and shaking intensity following earthquakes in Indonesia. This tool has been also used extensively to generate ShakeMaps for historical and/or hypothetical large earthquakes in Indonesia.

It is expected that both of these systems will continue to evolve in the years to come and it will be BMKG's responsibility to keep the systems up-to-date. Nevertheless, both systems are currently operational systems that are being used by BMKG to meet its mandated responsibilities on behalf of GoI with minimal input from GA. GA? considers these systems sustainable. In particular, the capability for the collection, analysis and storage of strong motion data within BMKG has progressed significantly over the project. BMKG has a lifetime licence for the SIGMA module (the software module used for strong ground motion archiving and analysis) and 3 years of free updates and technical support (up to 2020) from the software developer GEMPA. After this time they will need to budget for technical support for this software. BMKG is aware of this future cost.

This Program had a third component to initiate discussions for coordinated GoI capture of post-event damage data following Indonesian earthquakes. The systematic collection and analysis of such data is critical to Indonesia meeting its aspirations to better understand seismic risk. GA coordinated a workshop on the collection of exposure data through post-disaster surveys in November 2017. During this workshop consensus was reached on roles and responsibilities in undertaking post-disaster surveys. Further work is required by these agencies to formalise and implement these roles and responsibilities. It remains to be seen if this will be achieved sustainably without further intervention from external expertise/facilitators. However, given the strong ties built through collaborations on the National Earthquake Hazard Map, it is hoped that PuSGeN agencies will continue to work together in this space and that collaboration on this will continue.

2.3 Effectiveness

The effectiveness of the GA led activities to enhance the use of credible science to inform disaster management decisions has been illustrated through multiple achievements across the project. Some of these include:

- The completion and release of a new National Earthquake Hazard Map. The map was produced using the latest science and international best practice hazard modelling available for Indonesia. This will be used to inform Indonesian Building Codes for buildings and key infrastructure.

- The Indonesian Tsunami Warning System (InaTEWS) is now an operational system with consistent coverage for all of Indonesia and therefore contributing to the safety of millions of Indonesian's that live near the coast.

- BG is now recognised as an authority on tsunami inundation hazard maps. Based on this recognition they have been requested to provide updated hazard information to support infrastructure development decisions, including high profile national projects such as airports, ports and energy generation facilities. For example, BMKG and BG worked collaboratively to provide advice on tsunami mitigation for the construction of a new airport in Kulon Progo.

- BNPB has embraced OSM data and hosted their own mapathons to support disaster management decisions during the Mt Agung crisis. Furthermore, some provincial (BPBD) offices can manage their own OSM tasking requests. This proven capacity within Indonesia is expected to continue to inform disaster management decision making within BNPB and BPBDs across the country.

- BMKG continues to release ShakeMaps in real-time following earthquake events in Indonesia, which are being using to help inform disaster management decisions. For example, this functionality proved critical during the response of the Magnitude 6.5, 7 December 2016 Pidie Earthquake.

- Collaboration between BG and the Volcanic Ash Advisory Centre at BoM has increased substantially, enabling the sharing of observations of volcanic activity from the ground (from BG to BoM) and from satellite remote sensing (from BoM to BG). This sharing of data is currently happening for all significant eruptions in Indonesia.

- The GREAT program trains high quality scientists at ITB, with the quality of the research significantly increased through collaboration with ANU. The 40 graduate students that have benefited from this activity are now developing stronger evidence based disaster management in Indonesia. Moreover, the strengthened education system in ITB will continue to develop experts with relevant skills into the future.

2.4 Efficiency

During the leadership of this program GA sought to identify and exploit efficiencies wherever possible. Notable examples include:

- Coordination between GA, BNPB, GoI technical agencies and implementation partners to plan, schedule and deliver activities. This facilitated the management of contributions from partners (e.g. universities participating in mapathons and InaSAFE version releases) to meet BNPB priority programs and planning needs. GA invested in activities that were of a direct interest to GoI partners, therefore increasing collaboration and co-investment from GoI.

- As GoA officials, GA staff understand the pressures of operating in a technical capacity within agencies that deliver government mandated activities and services. The efficiency of peer-to-peer

engagement between GA staff and GoI technical officials benefited greatly from this shared understanding.

- In developing the capacity of GREAT, Australian scientists supported ITB student research. This leveraged student interest because they were individually motivated to graduate. It also created research that fed directly into other parts of the program, particularly Activity 4.1 and the National Earthquake Hazard Map.

- Efficiency of the activity was further enhanced by the opportunity for obtaining additional funding through Australian Research Council proposals to undertake research that will extend the scope of the projects done by GREAT/ITB students. Further efficiencies were identified, such as the use of funding from the grant ($140K) to leverage additional funding from the ANU ($155K) to purchase a joint instrument pool (the AITO) which is intended to support GREAT research until 2027.

- Efficiency was greatly improved between the volcanic ash modelling team (GoI and GoA) and the InaSAFE team who worked across a number of time zones via online messaging and innovative software development tools (e.g. GitHub) and video-conferencing. In this way a great deal of progress was made between face-to-face meetings.

- The new Tasking Manager for OSM, which was developed by implementation partner HOT, delivered efficiencies by sharing the cost of mapping projects with other interested parties around the world. The new version gains efficiencies in the mapping process by making it easier to manage tasks and validate mapping.

- Efficiencies were gained in the tsunami activities by aligning activity timelines with the International Tsunami Symposium in Bali; workshop held, and meetings with other partners that were present to discuss and plan for other aspects of the program, including the InaTEWS system and earthquake hazard assessment.

It is useful to note that for projects like DMInnovation, with multiple intergrated components, success is supported by regular contact and face-to-face meetings. This can be achieved with short term missions once relationships are established. However, it was our observation that the completion of GA deployments to Indonesia in June 2017 led to a decrease in the efficiency of management of the project due to significantly less face to face time with partners, reduced overlapping office hours due to the time difference and relying on internet connections (for example for Skype meetings, which were not always reliable). In contrast, some efficiencies were gained through having all GA employees on the project in one office.

2.5 Monitoring and Evaluation

The monitoring and evaluation framework set up for the DMInnovation project had several components:

- *Annual Work Plans (AWPs)*: these were signed by both DFAT and BNPB. The Programs and Activities listed in the AWP are reported against in this report.

- *Terms of Reference (ToRs)*: these were developed for each Program under the DMInnovation project and were finalised and signed/endorsed by BNPB. These documents covered the life of the program.

- *Project Management Units (PMUs)*: a PMU was established for each of the Programs (1 to 5) and there was a PMU head in BNPB responsible for each one. They had responsibility for signing the ToRs for each of these, including the associated budget. PMU meetings were held in 2017 for each PMU (1 through 5) with BNPB. Unfortunately, the PMU model was not supported by BNPB

as well as GA would have liked and DFAT and DMInnovation in-country staff had difficulty scheduling follow-on PMU meetings.

- GA Progress Reporting was yearly in financial years 2014-15 and 2015-2016 and six-monthly thereafter.

- Reporting on Competency and Gender. In 2016 the hazard programs established methods for capturing data on competency and gender of participants. The detail for these is included in Volume 2 of this Completion Report. Significant work was undertaken with implementation partners Kartoza and HOT to improve their reporting on competency and gender, and improvement in this area was realised in 2017.

- Reporting on mapping activities: This was undertaken by HOT and easily obtained from the systems that they have in place to count increases in the number of buildings and roads mapped in Indonesia, and the locations of these.

3 Cross Cutting Achievements and Adherence to DFAT Guidelines

GA adhered to DFAT's zero tolerance on fraud and child protection policy throughout the project and continued to identify and respond to risks. GA ensured its partners, HOT and Kartoza, were familiar with DFAT's policy. All implementing partners agreed to adhere to these policies at the time of contract/grant signing. Furthermore, advice from DFAT was forwarded to implementing partners as new advice was provided to GA.

All procurement and recruitment took place in line with GoA procurement and recruitment guidelines. The DMInnovation office at Menara Thamrin had in place compliant Workplace Health and Safety policy and procedures that meet the Work, Health and Safety Act requirements.

Specific cross-cutting achievements are summarised as follows:

- *Engaging the Private Sector:* The breadth of program achievements could not have been covered without significant contribution from the private sector particularly in the areas of logistics and software development. Contributions from the university and non-government sectors have also proved critical to program delivery.

- *Supporting Private Sector Growth:* Reinsurance companies base premiums and undertake risk assessments using best available hazard and risk information. The national earthquake and tsunami hazard maps developed through this project represent the best available understanding of hazard in Indonesia. As such, GA understands that these new hazard maps are being adopted by global reinsurance and insurance companies to assist them develop markets in Indonesia and price coverage according to best available information. Moreover, GA understands that two GREAT graduates have attained employment within the Indonesian insurance sector and more are likely to follow as the industry, which is currently small for the size of the population, is expected to grow.

- *Innovation:* Our program has focussed on delivering innovative solutions for disaster managers. For example:
  o By assisting disaster managers access information previously only widely available to scientists InaSAFE won the DFAT's Indonesia innovation award for the Most Innovative Online Platform in 2017, and the 2013 Black Duck Open Source Rookie of the Year Award in 2013 from a global field of candidates.
  o By using Crowd-Sourcing initiatives, GoI agencies mapped an unprecedented number of buildings and roads and directly informed flood management and response in Jakarta.
  o Guidelines were developed in Indonesia for the use of digital elevation data in tsunami inundation modelling and are now being adopted internationally. These guidelines inform the adoption of new technologies such as drones in elevation mapping.
  o High performance computing solutions were deployed across a range of hazard activities facilitating, for the first time, large scale modelling in Indonesia. This infrastructure has been gifted to The Ministry of Public Works and Housing and BMKG. Partners have been trained in their use and supported to budget for ongoing maintenance and potential replacement.

- *Safeguarding infrastructure:* The national earthquake hazard map will form the basis for the revision of Indonesian building codes, leading to a reduction in risk of damage to natural disasters

and safer communities. Similarly the volcanic and tsunami hazard products are being used to inform decisions around critical infrastructure siting and design including airports, power generation facilities and ports.

- **Supporting the Vulnerable and Underrepresented:** Disasters disproportionally impact the poorest and most vulnerable members of society. The DMInnovation project delivered training for underrepresented and vulnerable communities.
  - o We encouraged the inclusion of women in all aspects of the program and ran women only participatory mapping activities in February and November 2017. Similarly, we ran a participatory mapping initiative with the Young Persons with Disabilities Association in April 2017. Detailed statistics for the DMInnovation programs are provided in Volume 2.
  - o We enhanced InaSAFE functionality to generate impact reports disaggregated by gender, disability and age ensuring that disaster managers can consider the impact on the vulnerable when undertaking planning and response activities.
  - o We supported and actively encouraged partner organisations to include female participants in all GA led training exercises.

- **Sustainability:** The early phase of our collaboration focussed on pilot studies and testing new ideas and innovations. The program has gradually progressed through proof of concept to a strong focus on sustainability post program. The incorporation of spatial data, advanced hazard modelling and use of InaSAFE are all expected to continue to inform Indonesian disaster management sustainably into the future.

- **Mature partnership:** The Indonesia-Australia partnership on science and technology for disaster management is a mature relationship. Knowledge and experience is translated in both directions with Australia benefiting significantly also. For example:
  - o We have observed an increased use of open source software within GA as a direct result of experience gained working in Indonesia. This has the potential to save on license fees and in some cases lead to improved outcomes. For example, GA has simultaneously started using new earthquake hazard modelling software in both Indonesia and Australia leveraging limited resources and learning opportunities to serve both countries.
  - o The tsunamagenic sources that can potentially impact Northern and Western Australia are the same as those impacting Southern Java and Western Sumatra. Collaborative efforts to understand these sources has led to safer Australian and Indonesian communities. For example, the Australian tsunami hazard map, which is currently under development, is using many of the same sources as those used in the Indonesian tsunami hazard map. This outcome is good for both countries and only occurred because of the DMInnovation project.
  - o Australia has successfully migrated software for its management, acquisition and processing of earthquake data to Seiscomp3. The same software being used in BMKG and have benefited from the opportunity to interact with Indonesian systems ahead of our own migration.
  - o Indonesian volcanos directly impact the international aviation industry with many Australia bound flights crossing Indonesian territories. They also impact Australian tourists, and in some cases can directly drop ash on Australian territories. Our collaboration has enhanced dialogue between the Indonesian and Australian agencies that manage ash related hazards improving the flow of information in both directions and assisting a more robust regional management approach. This improves outcomes for Australian tourists, Australian tourism and the airlines that operate over Indonesian air space.

4 Summary of Short Term Missions

Short-term missions are conducted in two modes:

1. GA technical staff providing support to activities either through travel to Indonesia OR partners travelling to Australia (funded through GA, Canberra)
2. DMInnovation staff, both GA posted officers and locally engaged staff, travelling either within Indonesia or internationally to provide support to the activities (funded through DFAT, Jakarta).

A summary of these missions is provided in the following sections and the detailed travel reports are included in Appendices B and C in Volume 2 of this report.

4.1 Missions unded through GA, Canberra, 2014-18

2014

Dates	Officers	Locations	Purpose
31st August – 15th September	Dr Adele Bear-Crozier Dr Victoria Miller	Jakarta, Manado, Yogyakarta	Activity 4.4: Volcanic hazard
12th to 25th October	Mr Jonathan Griffin Ms Rikki Weber	Jakarta, Bandung	Activity 4.2: Tsunami hazard
9th to 14th November	Dr Mark Leonard	Jakarta, Bandung	Activity 4.1: Earthquake hazard
18th November to 4th December	Prof. Phil Cummins	Jakarta, Bandung	Activity 4.1: Earthquake hazard
14th to 20th December	Dr Hadi Ghasemi	Jakarta	Activity 4.1: Earthquake hazard

2015

Dates	Officers	Locations	Purpose
25th January to 5th February	Prof. Phil Cummins	Jakarta, Bandung, Palu	Activity 4.1: Earthquake hazard
25th January to 6th February	Mr Jonathan Griffin	Jakarta, Bandung	Activity 4.2: Tsunami hazard
1st to 7th February	Dr Hyeuk Ryu	Jakarta	Activity 4.1: Earthquake impact
21st to 27th February	Dr Adele Bear-Crozier	Jakarta	Activity 4.4: Volcanic hazard
11th to 18th April	Dr Adele Bear-Crozier	Bima	Activity 4.4: Volcanic hazard
2nd to 16th May	Dr Charlotte Morgan Dr David Robinson	Canberra, Sydney (from Jakarta Post)	Project Management
17th to 22nd May	Ms Rikki Weber	Jakarta	Activity 4.2: Tsunami hazard

Dates	Officers	Locations	Purpose
6th to 18th June	Mr Jonathan Griffin	Pangandaran, Bandung	Activity 4.2: Tsunami hazard
14th June to 4th July[1]	Prof. Phil Cummins	Bandung, Pavia – Italy, Prague, Czech Republic	Activity 4.1: Earthquake hazard
24th August to 4th September	Prof. Phil Cummins Dr Hadi Ghasemi	Jakarta	Activity 4.1: Earthquake hazard
5th to 12th September	Ms Rikki Weber	Jakarta	Activity 4.2: Tsunami hazard
6th to 22nd October	Prof. Phil Cummins	Jakarta, Banda Aceh & Bandung	Activity 4.1: Earthquake hazard training UNESCO assessment Aceh Tsunami Museum
6th to 15th October	Dr Charlotte Morgan	Canberra & Perth	Programs 1 and 2: 8th Australasian Natural Hazards Management Conference
24th October to 4th November	Dr Hadi Ghasemi Pak Masyhur Isryam (ITB)	Pavia, Italy & Jakarta	Activity 4.1: GEM annual risk workshop
24th October to 8th November	Dr Jane Sexton	Jakarta	Project Management: Science Review

2016

Dates	Officers	Locations	Purpose
24th January to 5th February	Badan Geologi Staff (x3)	Melbourne (hosted at BoM by Adele Bear-Crozier)	Activity 4.4: Volcanic ash hazard
31st January to 14th February	Dr Hyeuk Ryu Prof. Phil Cummins	Bandung	Activity 4.1: Earthquake hazard
31st January to 5th February	Dr Hadi Ghasemi	Jakarta	Activity 4.1: Earthquake hazard
28th March to 4th April	Ms Libby Metz	Jakarta	Program 2: Kartoza InaSAFE development meeting
10th to 16th April	Prof. Phil Cummins	Bandung	Activity 4.1: Earthquake hazard
14th to 22nd May	Dr Charlotte Morgan	Venice	Programs 1 and 2: Understanding Risk Forum
15th to 27th May	Dr Adele Bear-Crozier[2]	Denpasar, Bandung & Jakarta	Activity 4.4: Volcanic ash hazard
12th to 25th May	Prof. Phil Cummins Dr Hadi Ghasemi	Bandung & Jakarta	Activity 4.1 & Program 5: Earthquake hazard
20th June to 2nd August	Dr Jane Sexton	Jakarta	Project Management: All programs
31st July to 3rd August	Prof. Phil Cummins	Bali	Activity 4.1: Earthquake hazard
30th July to 7th August	Dr David Robinson	Canberra	Project Management: All programs
10th August to 16th September	Ms Lauren Power	Jakarta	Programs 1 and 2: InaSAFE and Spatial Data
19th August to 3rd September	Prof. Phil Cummins	Bandung & Jakarta	Activity 4.1: Earthquake hazard

Dates	Officers	Locations	Purpose
29th August to 9th September	Badan Geologi Staff (x3)	Canberra	Activity 4.2 Tsunami hazard
23rd to 29th October	Prof. Phil Cummins	Bandung & Jakarta	Activity 4.1: Earthquake hazard
29th October to 5th November	Dr Hadi Ghasemi Prof. Masyhur Irsyam (ITB)	Beppu, Japan	Activity 4.1 & Program 5 Earthquake hazard
30th October to 4th November	Mr Tony Pack	Jakarta & Bandung	Project management Office closure and IT assets
30th October to 4th November	Ms Rikki Weber	Jakarta	Activity 4.2 Tsunami hazard
29th November to 3rd December	Dr David Robinson	Pavia, Italy	Activity 4.1 & Program 5 Earthquake hazard

2017

Dates	Officers	Locations	Purpose
7th to 18th February	Prof. Phil Cummins	Jakarta and Bandung	Activity 4.1 NEHM and Program 3: GREAT
19th to 25th February	Ms Rikki Weber	Jakarta and Bandung	Project Management Activities 4.2, 4.3, 4.4 and 2.1
26th February to 4th March	Dr Hadi Ghasemi	Jakarta	Program 5: ShakeMap
2nd to 13th April	Prof. Phil Cummins Dr. Hadi Ghasemi	Jakarta and Bandung	Activity 4.1: NEHM and Program 3: GREAT
7th to 13th May	Ms Rikki Weber Dr Victoria Miller	Jakarta	Activity 4.4: Volcanic Ash Forecasting
19th to 30th June	Prof. Phil Cummins Lutfi Faizal (PU) Prof. Masyhur Irsyam (ITB)	Pavia, Italy and Potsdam, Germany	Activity 4.1: GEM membership and Program 5: Gempa contract
23rd to 29th July	Prof. Phil Cummins Dr Hadi Ghasemi	Jakarta and Bandung	Activity 4.1: OpenQuake and Program 5: Strong motion
6th to 12th August	Dr Hadi Ghasemi	Jakarta	Program 5: Seiscomp3
15th to 24th August	Ms Rikki Weber Mr Jonathan Griffin	Bali	Activity 4.2: tsunami inundation modelling
4th to 7th September	Dr Charlotte Morgan	Jakarta	Program 1 and Program 2: Project Management
17th to 29th September	Dr Charlotte Morgan	Jakarta	Program 1: Training curriculum, Program 2: InaSAFE capacity building with BNPB
12th to 24th November	Prof. Phil Cummins Dr Hadi Ghasemi	Jakarta and Bandung	Program 3: GREAT and Program 5: Post disaster surveys
10th to 16th December	Eko Yuliatno (LIPI)	Canberra, Australia	Activity 4.2: source zones on Java trench for tsunami
18th to 23rd December	Prof. Phil Cummins	Jakarta and Bandung	Program 3: GREAT, Program 5: Post disaster surveys

2018

Dates	Officers	Locations	Purpose
28th January to 3rd February	Dr Charlotte Morgan	Jakarta	Program 1: OSM and Program 2: InaSAFE
18th February to 24th February	Ms Imun Maemunah, BG Ms Merry Christina Natalia, BG Ms Arianne Pingkan Lewu, BG Mr Robiana Rahayu, BG Mr Pandu Adi Minarno, BG Ms Weniza, BMKG Dwi Hartanto (BMKG) Mr Indra Gunawan, BMKG	Canberra	Activity 4.2: Tsunami Inundation
23rd April to 27th April	Mr Ryan Pranantyo[3], ANU	Jakarta	Activity 4.2: Tsunami Inundation
1st to 10th May	Dr David Robinson Dr Andy Barnicoat[4]	Bandung and Jakarta	All programs
13th to 22nd May	Dr Hadi Ghasemi	Miami, USA	Program 5: ShakeMap
3rd to 9th June	Prof. Phil Cummins	Jakarta	Activity 4.1: Earthquake hazard
3rd 12th June	Dr David Robinson	Jakarta and Bandung	All programs

1. Travel components that were outside Indonesia were not invoiced to AIFDR unless specifically mentioned
2. Cost for this trip were shared with the Australian Bureau of Meteorology
3. ANU led this workshop on behalf of GA who were unable to send a staff member on this occasion. ANU did so without any salary charges. GA funded the travel costs from the AS34 budget.
4. Chief, Community Safety and Earth Monitoring Division (costs for the Chief's travel was funded by the GA management budget)

4.2 Missions funded through DFAT, Jakarta, 2014-18

2014

Dates	Officers	Locations	Purpose
10th to 11th November	Mr Ignatius Ryan Pranantyo Ms Mahardika Fadmastuti	Bandung	InaSAFE applications
17th to 20th November	Mr Fredy Chandra	Surabaya	Risk assessment workshop

2015

Dates	Officers	Locations	Purpose
19th to 23rd January	Mr Fredy Chandra Dr Charlotte Morgan	Sampang & Situbondo, East Java	Exposure data development
1st to 4th February	Ms Tini Astuti Mr Henry Pirade Dr David Robinson	Lembata and Larantuka, East Nusa Tenggara (NTT)	Local level DRM preparations
14th to 18th March	Dr David Robinson Mr Henry Pirade Mr Fredy Chandra	Sendai, Japan	World Conference on DRR - Sendai, Japan

Dates	Officers	Locations	Purpose
11th to 16th May	Mr Fredy Chandra Mr Adi Kurniawan	Timor Tengah Utara, NTT	Risk assessment workshop
25th to 29th May	Mr Fredy Chandra	Nagekeo, NTT	Risk assessment workshop
8th to 10th June	Mr Fredy Chandra	Makasar, South Sulawesi	Risk assessment workshop
16th to 18th October	Charlotte Morgan Adi Kurniawan	Solo	DRR month in Solo
25th to 26th November	Adi Kuriawan	Yogyakarta	Symposium National Science Geoinformation
16th to 18th December	Fredy Chandra Adi Kurniawan Aditya (HOT) Harry Mahardika (HOT)	Sentul	InaSAFE development

2016

Dates	Officers	Locations	Purpose
11th to 12th February	Mr Fredy Chandra Adi Kurniawan Harry Mahardika (HOT) Elida Nurohma (HOT)	East Jakarta	InaSAFE institutionalisation
18th to 20th May	Mr Fredy Chandra	Ambon	InaSAFE institutionalisation and Ambon Tsunami TTX
23rd to 24th May	Radhietya Hadikusuma (DFAT) Dr David Robinson	Bandung	Annual Scientific Meeting at ITB
24th May	Mr Fredy Chandra	Bali	InaSAFE institutionalisation
1st to 3rd June	Mr Fredy Chandra Adi Kurniawan	Ambon	InaSAFE institutionalisation
8th to 10th August	Mr Fredy Chandra	Ambon	Activity 2.2 Targeted BNPB Support
19th to 21st August	Dr David Robinson	Bandung	Activity 4.1 Earthquake Hazard
30th to 31st August	Mr Fredy Chandra Mr Piter Edward	Ambon	Activity 2.2 Targeted BNPB Support
6th October	Mr Fredy Chandra	Jakarta	Activity 2.2 Targeted BNPB Support
12th to 15th October	Dr Charlotte Morgan Mr Fredy Chandra Mr Adi Kurniawan	Manado	Programs 1 and 1
25th to 27th October	Dr David Robinson	Bandung	Activities 2.2, 4.1, 4.2, 4.4 and 5.1
2nd to 3rd November	Dr David Robinson Mr Simon Field Mr Tony Pack Mr Rangga	Bandung	Project management Office closure and IT assets
29th to 30th November	Mr Fredy Chandra Mr Adi Kurniawan Mr Felix Yanuar Mr Ivan Busthomi	Jakarta	Programs 1 and 2
18th November	Mr Adi Kurniawan	Jakarta	Programs 1 and 2
22nd December	Mr Fredy Chandra	Solo	Programs 1 and 2

2017

Dates	Officers	Locations	Purpose
23rd to 25th October	Adi Kurniawan Felix Yanuar Endro Wicaksono Ivan Busthomi Danang Wijaya (BNPB)	Sorong	Program 1: OSM and Program 2: InaSAFE
14th to 15th November	Adi Kurniawan	Bandung	Program 5 and Program 2: post disaster information in InaSAFE
19th to 25th November	Adi Kurniawan and Felix Yanuar Endro Wicaksono	Padang	Program 2: InsaSAFE and community and sustainability
22nd December	Ivan Busthomi	Yogyakarta	Program 2: InaSAFE academic community and sustainability

5 Acknowledgements

GA wishes to acknowledge and thank the DFAT Development Program for funding the DMInnovation project. We acknowledge our Government of Indonesia partners for their contribution towards the shared goals of these activities. This program has been delivered in partnership with many collaborators as summarised below:

GA would like to highlight that the success of these activities would not have been possible without the hard work of our contract and grant implementation partners: Kartoza; Humanitarian OpenStreetMap Team (HOT); The Alfred Wegner Institute; Gempa; University of Wollongong; Institut Teknologi Bandung (ITB); The Australian National University (ANU); North Road; and the Fall3D Development Team.

Finally GA would like to thank Simon Field, the Project Director and the HKL/Palladium team, who formed a significant part of the DMInnovation Family during Phase 3 of the program.

The completion of the DMInnovation project concludes the 10 year partnership between GA and the Government of Indonesia partners on disaster management. Over those 10 years, GA has forged strong and enduring relationships with science and technical agencies at both organisational and personal levels. GA welcomes opportunities to continue partnering with the Government of Indonesia in the future to help Australia and DFAT reach its Development Program goals in the Indo-Pacific region.