Global Facility for Disaster Risk Reduction

Global Program for Safer Schools

Indonesia Mission Report

238204-01 I R01

Issue | 6 March 2015

Job number 238204-01

Ove Arup & Partners International Ltd
www.arup.com

ARUP

Document Verification

ARUP

Job title		Global Program for Safer Schools		**Job number** 238204-01	
Document title		Indonesia Mission Report		**File reference**	
Document ref		238204-01 I R01			
Revision	**Date**	**Filename**			
Draft 1	20 Jan 2015	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Joseph Stables	Hayley Gryc	Jo da Silva
		Signature			
Issue 1	6 Mar 2015	**Filename**			
		Description	Updated to incorporate comments from World Bank country Task Team in Indonesia (13/02/2015) and the Australian Department of Foreign Affairs and Trade (19/02/2015)		
			Prepared by	Checked by	Approved by
		Name	Joseph Stables	Hayley Gryc	Jo da Silva
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Executive Summary

Indonesia was identified by the World Bank (WB) as a country for Arup to provide technical support to the WB country task team to inform the development of a GPSS TA program. The aim of this study is to get an informed understanding of the structural vulnerability of Indonesia's existing public schools facilities and contributing factors of risk. The observations made in this report are the result of an 8 week study carried out by Arup which included a desk study, field mission and analysis of findings and documentation.

Indonesia is an archipelago in South East Asia comprising more than 6000 inhabited islands covering 800,000 square miles of land with a variety of different geographies, cultures, construction materials and school building typologies. It is in a multi-hazardous region with frequent earthquakes and a history of tsunamis, volcanoes, landslides and flooding which affect school infrastructure in different ways. The WB Safe Schools Pilot Project estimated that 75% of school buildings in Indonesia are in a hazard zones.

With over 300,000 schools in Indonesia there remains a severe shortage of capacity which is not being addressed by the current supply. There was evidence of overcrowding in both rural and urban schools, some of which had temporary classrooms funded and built by parents and teachers to cope with the demand.

A total of 21 schools were visited which can be categorised into five construction typologies; Unreinforced Masonry; Confined Masonry; Concrete Moment Frame; Timber Haunched Frame; Lightweight Steel Frame. Although all were found to have some vulnerabilities, unreinforced and confined masonry were most vulnerable. This is further compounded by poor quality construction, site selection and physical planning.

Five funding streams for delivering new school infrastructure and repairing damaged school infrastructure in Indonesia were identified; the most common being through national funding from the Ministries of Education and Culture, Religious Affairs, and Finance. There are various challenges in these implementation processes, which include planning, design and construction of new schools and assessing and repairing existing school infrastructure.

AusAid have provided technical assistance to the construction of approximately 1200 new schools. Various INGOs are also active players in the implementation of school infrastructure but with limited impact at scale.

In order to achieve a large scale solution which has a short, medium and long term strategies we recommend developing a **National Strategic Plan for Safe Schools** (NSPSS) which addresses the following;

1. Existing schools;
    - in a state of repair or damaged from disasters and
    - those that are in good condition and
2. New school construction

1 Introduction

Each year, natural disasters result in school buildings being destroyed or severely damaged leading to loss of life, injury and disruption to education. Global efforts to make schools more resilient have largely focussed on improving awareness and preparedness, so that teachers and children are better placed to take appropriate action in the event of a disaster. Less attention has been paid to the physical performance of school buildings, which is the focus of a new initiative by the Global Facility for Disaster Risk Reduction (GFDRR) - the Global Program for Safer Schools (GPSS). This is being designed as a technical assistance (TA) program targeting countries where there is on-going or proposed investment in school infrastructure. The WB had carried out an existing Safe School Pilot (TA) Project in Indonesia that integrated DRR in to school infrastructure in 2012 as there was recognition of the risk imposed by natural disasters and that more efforts are required to make schools resilient to these disasters. Following this and the new government administration is promoting education as a priority Indonesia was identified by the World Bank (WB) as a country for Arup to provide technical support to the WB country task team to inform the development of a GPSS TA program.

The aim of this study is to get an informed understanding of the structural vulnerability of Indonesia’s existing public schools facilities and contributing factors of risk.

The objectives are:

1. To understand the range of hazards and drivers of risk that may compromise the planning, design, construction, repair and retrofitting, and operation of school infrastructure projects.
2. To understand the number and construction typology of existing schools in Indonesia (including the number of damaged schools) and those that will be constructed.
3. To understand the current safe school practices in Indonesia which relate to in disaster preparedness, repair, rehabilitation and retrofitting.
4. To understand the institutional environment and regulatory framework within which school infrastructure is planned, designed, constructed, operated, maintained, repaired and retrofitted in Indonesia.
5. To make recommendations to the WB country task team to prioritise the GPSS investment for a structural resilience program of construction and rehabilitation for public schools facilities.

2 Context

Indonesia is an archipelago in South East Asia comprising more than 6000 inhabited islands covering 800,000 square miles of land with a variety of different geographies, cultures, construction materials and typologies. It is the fourth most populous country in the world with a population of 252 million which is growing quickly at 2% per year. 60% of the population is concentrated on the Island of Java which has a population density of nearly 2,500 people per square mile making it the most populous island in the world. Urbanisation has been increasing steadily since 1970s and there are now 11 cities with a population greater than 1 million, with 10 million people living in the capital Jakarta.

Indonesia is located on the edges of the Pacific, Eurasian, Philippine and Australian tectonic plates and is extremely hazardous. There is a long and tragic history of earthquake and tsunami events culminating in the 9.2 magnitude earthquake in 2004 off the coast of Sumatra which generated a large tsunami and killed 225,000 people. More recently earthquake events in 2006 in Java and 2009 in Sumatra have resulted in more than 1,000 deaths, and other earthquakes exceeding 8.0 magnitude have been recorded in 2007 in Sumatra and 2012 off the coast of Sumatra. There is now an increasing recognition of the risk to school infrastructure posed by natural disasters.

Indonesia has a decentralised governance system that has evolved since the 1990s consisting of 34 provinces, each with its own legislature and governor. These provinces are subdivided into administrative District and Cities resulting in more than 500 decision makers at local level. A new president was elected in 2014, and the new government administration has identified education as a key priority. The education budget is currently earmarked in the Constitution as 20% of annual budget and so there is an opportunity for the World Bank to align a GPSS TA program with existing investment in school infrastructure.

The national Inpres school building program was initiated in the 1970s and continued to the 1990s. This responded to the rising demand for school places, driven by compulsory education being was introduced in 1980s, initially for 6 years and then increased to 9 years; rather than providing quality resilient school infrastructure. Since decentralisation the implementation of school infrastructure has become the responsibility of the Districts and Cities who are still playing catch up with the demand for school places. There is now an aspiration in the new Government to increase compulsory education to 12 years.

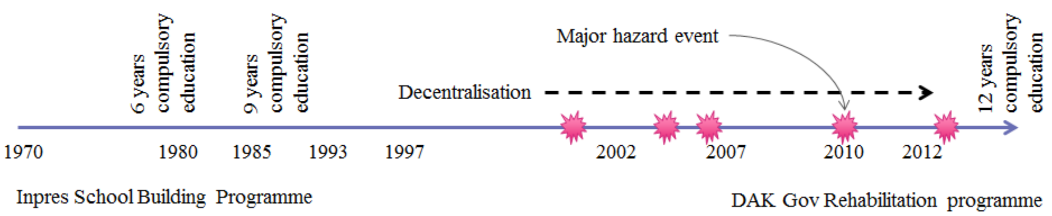


Figure 1 Timeline showing school infrastructure programs, the introduction of compulsory education, the decentralisation process, and major hazard events

The scale and variety of contexts presents a formidable challenge for Indonesia to meet the increasing demand for school places whilst also ensuring schools provide a safe environment in the event of the extreme hazards they face.

3 Methodology

The observations made in this report are the result of an 8 week study carried out by Arup which included:

- Desk Study
- Field Mission
- Analysis of findings and documentation

Desk Study

Arup carried out a review of available documentation (Appendix A), and undertook a hazard study (Appendix B) to identify the range and intensity of hazards facing schools in Indonesia. This focussed on the areas visited during the field mission; in and around Padang, Sumatra and North and West Lombok.

Field Mission

A 10 day field mission was carried out by Arup Consultants, Hayley Gryc and Joseph Stables, from 1st to 10th December 2014.

Key stakeholder consultations included national and district government departments, school teachers, engineers, contractors, academics, donor organisations and INGOs. A full list of key stakeholder meetings is shown in the Mission Schedule in Appendix C.

During the mission a total of 21 schools (Appendix D1) were visited in order to gain an understanding of the different construction typologies and vulnerabilities; 9 schools around Padang (Kabupaten Padang Pariaman and Kota Padang, see Figure 2) and 12 schools around Lombok (Lombok Ultara and Lombok Barat, see Figure 3). These schools were selected by the WB country team in coordination with the Education District Offices and the Ministry of Religious Affairs. The schools were chosen to represent a variety of typical school facilities in terms of the school size, construction typology, building condition and exposure to hazards.

The data collected during the school visits (Appendix D2) was used to conduct a rapid visual assessment using FEMA 154 (Appendix D3) on at least one building from each school. The purpose of this assessment was to obtain a high level understanding of the vulnerability of school infrastructure in Indonesia to earthquake risk.

Figure 2 School locations around Padang

Figure 3 School locations around Lombok

Initial observations and recommendations were shared with the WB country task team at the end of the field mission. Feedback was provided and incorporated into a final presentation which was issued following the field mission (Appendix E).

Analysis

An analysis of the key findings, including review of further documentation obtained, was carried out following the field mission, and summarised in this report.

4 Key findings

4.1 Hazards

Indonesia is in a multi-hazardous region with frequent earthquakes and a history of tsunamis, volcanoes, landslides and flooding (refer to Appendix B) all which affect school infrastructure in different ways. The WB Safe Schools Pilot Project estimated that 75% of school buildings in Indonesia are in a hazard zones[1].

Earthquake hazards pose a critical risk to school safety. There is a high earthquake hazard over 70% of the country affecting the majority of school infrastructure, which includes megathrust earthquakes that are caused by the Sunda fault line in the sea that runs in parallel to the west coast of Sumatra and Java. Through quality design and construction, the vulnerability of school infrastructure to earthquakes can be significantly reduced.

Land-sliding and liquefaction, in response to earthquake-induced ground shaking, are also significant hazards across Indonesia, particularly around the mountain ranges that run through many of the islands. Vertical displacements of the sea floor during megathrust earthquakes can also generate devastating tsunamis. The Sunda megathrust caused the 2004 tsunami and recent studies suggest sections of this system of faults are likely to generate the next major earthquake resulting in a high tsunami hazard along much of Indonesia's coastline; particularly along the west coast of Sumatra and Java and around the islands of the eastern provinces of Sulawesi, Moluccas and Papua[2]. Furthermore, Indonesia has 127 active volcanoes. The most effective means to reduce risk from landslides (and liquefaction), volcanoes and tsunamis is to minimise the exposure by locating schools away from these hazards. With 5 million people living within the volcano danger zones[3] and significant numbers living in tsunami zones it is recognised that this is not always possible. Early Warning Systems (EWS) can be effective in reducing the loss of life but not in reducing the risk to physical assets.

Indonesia's tropical climate is characterized by heavy rainfall causing frequent flooding especially in low-lying communities. The hazard level is medium to high[4] along the eastern side of Sumatra, the south west side of Kalimantan, and around the low lying areas of Java and Papua. Risks associated with low flood hazard level and localised flooding can typically be mitigated through appropriate design and construction of school infrastructure, whereas larger scale level flooding, for example due to storm surges, should be controlled by careful consideration of the site selection or disaster risk management strategies.

Hazard Awareness

The frequency, intensity and consequences of recent earthquakes and tsunamis have led to awareness of these hazards within communities and at district and

[1] Safe School Pilot Project in Indonesia, Survey of Preliminary Impact and Recommendation, Tata Mustasya

[2] http://geospasial.bnpb.go.id/wp-content/uploads/2012/10/2012-10 16_Hazardmap_Tsunami_risk_assessment_2011.pdf

[3] http://en.wikipedia.org/wiki/List_of_volcanoes_in_Indonesia

[4] http://geospasial.bnpb.go.id/wp-content/uploads/2012/10/2012-10-16_Hazardmap_Flood_risk_assessment_2011.pdf

national level. Earthquake engineering has been taught at universities for a long time and Indonesia is becoming a hub for international research.

Education Policy and disaster response planning respond well to both Pillar 2 (School Disaster Management) and Pillar 3 (Risk Reduction and Resilience Education) of the Comprehensive School Safety Framework[5]. The National Board for Disaster Management (BNPB) have developed national hazard and risk maps for Indonesia for earthquake, tsunami, volcano, landslide, and flood hazards. These were developed for disaster risk management purposes in order to develop national response and recovery plans. There was evidence in Padang of an established Tsunami EWS and a school designed and built as a tsunami shelter (JICA SND 23, 24 Kota Padang). We also witnessed well-rehearsed earthquake evacuation drills in many of the schools visited.

School infrastructure in Indonesia remains vulnerable, presenting a risk to lives and hampering the recovery of education following a hazard event. Pillar 1 (Safe Learning Facilities) requires more attention to improve the safety of school facilities at scale. The District Board for Disaster Management (BPBD), with guidance from the National and Provincial level, are responsible for the preparation of more detailed hazard and risk maps for each District but these do not appear to have been developed yet in the districts visited. The Arup hazard studies (Appendix B) of Padang and Lombok have shown that the national scale mapping does not identify local hazards in sufficient detail to inform site selection and planning to mitigate hazards and identify the most exposed schools.

Opportunity 1

More detailed hazard/ risk maps for each District are required for spatial planning purposes. Once local hazard maps have been produced, there is an opportunity to map the school locations against the hazard zones to quickly identify the most exposed schools. The production of district level hazard mapping requires coordination, GIS mapping, and some expertise and expense. An alternative option which may be more achievable in the short term would be to carry out site specific hazard assessments for particular school locations. For example, a flood study based on the surrounding land contours could be carried out to determine the flood hazard level. There is a rapidly developing global library of geospatial data which includes Indonesia and much of this is freely available. Accessing and interpreting this data requires expertise which could be provided through training and education :

- Digital topography and optical satellite imagery is available through http://earthexplorer.usgs.gov/ and http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp
- http://www.gebco.net/data_and_products/gridded_bathymetry_data/
- Earthquake data is available through http://earthquake.usgs.gov/earthquakes/ and http://ds.iris.edu/ieb/
- Remote sensing software is available commercially (ERDAS Imagine, ENVI, ARC GIS), and also for free (GRASS, QGIS)

[5] Comprehensive School Safety, A global framework in support of The Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector and The Worldwide Initiative for Safe Schools, UNISDR

4.2 School Capacity

Ministry of Education and Culture (MoEC) informed us that there are over 300,000 schools in Indonesia, including public schools, private schools, and Madrasah – religious schools provided by the Ministry of Religious Affairs (MoRA). These are typically split into primary (first 6 years), junior high (next 3 years), and senior high (last 3 years). The MoEC also revealed that there is a severe shortage in classroom capacity with 4,700 new junior high schools needed over the next 5 years. During our school visits there was evidence of overcrowding in both rural and urban schools, some of which had temporary classrooms funded and built by parents and teachers to cope with the demand. The shortage of school classrooms appears to be driven by:

1. The introduction of compulsory primary and junior high school education in the 1980s, combined with steady population growth, has led to increasing demand for school places, particularly primary and junior high school. This is expected to be exacerbated by the extension of compulsory education to 12 years. The current national plan is to provide 200 new junior high schools each year for the next 5 years resulting in a shortfall of 3700 new Junior High schools.
2. The lack of investment in maintenance over the last 30-40 years has led to school buildings in a state of disrepair. The MoRA estimate that 22.5% of Madrasah school buildings are heavily damaged and a further 35% in poor condition[6]. In 2010 the MoEC created an on-going special allocation fund (DAK) to address the maintenance issues across the country. This is focussed on repairing existing damaged school infrastructure back to their original condition, not necessarily strengthening them to be safer.
3. Damage from previous disasters has led to many school buildings being unfit for use. The Ministry of Finance (MoF) created an Endowment Fund to respond specifically to schools affected by disasters and in need of reconstruction. However there was no evidence that this is being used, and in the areas visited it appeared that the hazard damage was repaired using the DAK fund.

There is currently limited understanding of the vulnerability of existing schools (both damaged and undamaged schools) and no budget for a national retrofitting (strengthening) program. The MoECplan to develop a Revitalisation Pilot Project for 25 schools nationwide, budgeting 2 billion Indonesian rupiah per school to either repair, retrofit, or change the function of other buildings into school classrooms.

Opportunity 2

There is an opportunity to find creative short term solutions to help address the classroom shortage challenge. For example, in Ulaanbator (Mongolia) classes are operated in daytime shifts to enable more classes to use the same buildings at different times. There is also an opportunity to develop a model design for affordable and safe temporary (designed with a reduced lifespan to make them cheaper to build) classrooms to help address the shortfall.

[6] Mapping of Education, Madrasah Building Analysis, MoRA, June 2012

<u>Opportunity 3</u>

There is an opportunity to develop a nationwide retrofitting program, to make existing school infrastructure safer to natural hazards, which identifies the most vulnerable schools to be included in the government Revitalisation Pilot Program.

4.3 School Infrastructure

Construction Typology

The 21 schools visited (Appendix D1 & D2) can be categorised into five construction typologies

- Unreinforced Masonry
- Confined Masonry
- Concrete Moment Frame
- Timber Haunched Frame
- Lightweight Steel Frame

Schools constructed by the national MoEC Inpres program from the 1970s were typically built using unreinforced masonry. SND 3 Kedaro, in rural Lombok Barat, was built as part of the Inpres program using a light gauge steel frame with corrugated asbestos shear panel walls. It is likelylikely that this was a standard model constructed in some districts where availability of materials or accessibility issues rendered the masonry model unviable. The oldest school visited, SND 1 Kebon Ayu, Lombok Barat, was built in the 1940s during the Japanese occupation using a haunched timber frame.

With a greater understanding of earthquakes in recent years and the importance for school infrastructure to be resistant to earthquakes, the construction typology has developed and most schools are now constructed using confined masonry, or to a lesser extent concrete moment frame.

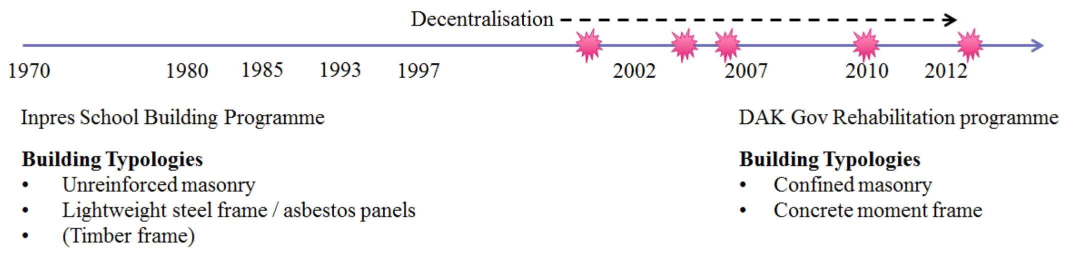


Figure 4 Timeline showing changes in building typologies, decentralisation, and recent major hazard events

Details of each of the different construction typologies and key observations that affect the vulnerability are highlighted in Table 1 and described in more detail below.

Table 1 Construction typologies of schools visited

Construction Typology	#	Photo	Advantages	Disadvantages
Unreinforced masonry (Inpres programme)	30%		• Easy to build • Durable	• Wall panels unrestrained (no ring beam and / or stiffener columns) • No seismic design
Confined masonry - concrete frame with masonry walls anchored to frame (Government model)	50%		• Seismic resistance if constructed properly and best practice details are followed • Durable	• Large openings compromise stability and do not follow best practice details • Complex rebar detailing
Concrete moment frame with masonry infill panels (e.g. JICA Shelter schools)	10%		• Seismic resistance • Durable • Allows large openings in walls	• Masonry façade may not be tied in • Very complex seismic reinforcement detailing
Timber haunched frame - half height unreinforced masonry walls on raised plinth (e.g. 1940s)	5%		• Lightweight is good for seismic • Easy to build • Quick to build	• Untreated timber susceptible to insect attack and weather degradation • Unrestrained masonry panels
Light steel frame with asbestos shear panels (Inpres programme)	5%		• Lightweight is good for seismic performance • Easy to build • Quick to build	• Untreated steel will corrode if not well maintained • Asbestos – issues with damage / removal

Unreinforced Masonry

Unreinforced Masonry is the most vulnerable construction typology seen during the field mission. Many of the unreinforced masonry schools visited were more than 30 years old, and were not adequately maintained or repaired following damage. This increases their vulnerability to future events; for example, cracked walls have less capacity and are less stable during subsequent earthquakes.

Confined Masonry

Confined masonry consists of masonry wall panels (unreinforced) anchored into reinforced concrete stiffener columns at regular intervals with a concrete ring beam at the top of the wall.

Confined masonry is more complicated to build than unreinforced masonry as it introduces reinforced concrete into the masonry wall panel. The reinforced concrete elements are often small and can be difficult to achieve good quality workmanship as seen on some sites during the school visits. The concrete can be difficult to compact, often resulting in air voids and exposed reinforcement which compromises the durability and capacity of the building structure.

Best practice seismic design details for confined masonry construction were often found to be neglected in the schools visited, including:

- Providing lintels or reinforced tie beams over large window openings to prevent the brickwork above from loosening

- Providing seismic reinforcement details such as, 45 degree hooked leg on shear links in concrete column and beams.

- Using deformed reinforcement. Smooth reinforcement is widely used for single/ two storey buildings. Whilst this is not international good practice for seismic design, it may be adequate for single storey buildings if engineering checks have been performed.

Concrete Moment Frame

Two of the schools we visited had buildings constructed using reinforced concrete moment frames with infill masonry wall panels. SND 23, 24, Kota Padang, was a 3 storey tsunami shelter built by JICA (Japan International Cooperation Agency) on the coast of Padang. Another double storey classroom block was seen under construction in Padang.

Moment frame construction is often more expensive to build than unreinforced or confined masonry, and requires a high level of quality control to ensure the concrete frame is constructed with special seismic and moment connection reinforcement detailing, which is often unfamiliar to local construction teams. The infill wall panels are not required to provide stability which means larger window openings can be provided. However, the wall panels must be detailed to prevent them falling out during a seismic event. This is often overlooked and poses a significant risk to users of the building.

Timber Frame

The timber frame school we visited was constructed using an engineered haunched frame with low level masonry infill walls allowing for large window openings. This lightweight frame performs well in a seismic event because there is little mass to excite, and the structure can accommodate movements without being damaged. The building was generally in good condition for its age (over 70 years old), although some of the timber elements had degraded significantly from insect attack, and these should be removed and replaced with new treated timber. It was not clear if the masonry infill panels were connected to the surrounding timber frame (e.g. through protruding nails or similar). If not, there is a risk of local collapse of the masonry infill panels in a seismic event.

Steel Frame

Similar to timber frame buildings, this lightweight form of construction is less excitable during an earthquake and therefore less vulnerable to damage than a heavier masonry building. The steel sections were badly corroded due to the age of the building and lack of maintenance and treatment. The panel walls were asbestos which can be extremely hazardous to health if the dust from the material is inhaled.

Opportunity 4

There is an opportunity to develop engineered model school designs for different construction typologies to provide a consistent and safe set of construction details. This could include a reinforced masonry option which is inherently easier to build than confined masonry. When considering what construction typology to use, it is important to consider the materials and skills available locally, as well as how to make it safe and durable. In Indonesia this is likely to vary considerably in particular areas so there is unlikely to be a one size fits all solution.

Other Building Elements

Foundations

Foundation settlement was observed in a handful of the schools visited. This can be avoided by designing foundations which are specific to the ground conditions found on site. For very soft ground in low lying areas school buildings may require larger pad/ strip foundations or deeper foundations that are founded on harder soil, such as piled foundations.

Roof Structure

Older roofs were typically made using timber trusses with tiles or corrugated sheeting. With timber becoming scarce in Indonesia due to deforestation, it is being replaced by light gauge steel roof frames. The construction details of the steel frames do not appear to be well understood with several of the schools we visited reporting roof coverings being blown off in the wind. Adequate connections using J-hooks or nuts and bolts should be used for steel connections rather than nails. Additionally the light gauge steel roof elements often struggle to support the load of construction or maintenance workers without being damaged. Thicker gauge steel elements should be used or a construction and maintenance strategy should be developed to ensure people don’t climb over the roof.

Non-Structural Elements

It is important to consider the non-structural elements (finishes, furniture and fixtures and fittings) within the school building and ensure that they are adequately fixed to the structure so they are not at risk of falling and injuring someone in the event of a seismic hazard. Asbestos was used for the ceiling cladding in a number of schools we visited and was often severely damaged, potentially posing a health risk to the building users.

Asbestos

Asbestos is a brittle material and does not perform well in an earthquake. Asbestos is no longer permitted to be used in many countries as respiratory problems can develop later in life and can even result in death. Care should be taken when dismantling existing asbestos buildings to avoid inhalation of fibres. New school and rehabilitated schools were seen to be replacing this material with non-hazardous plasterboard. It was not clear if the risks associated with working to remove the asbestos were well understood or whether the right safety precautions were in place to handle and dispose of it.

Construction Quality

The quality of workmanship largely depended on the skills of the labour force which varied widely depending on the availability and procurement of labour. Sufficient resources should be dedicated to ensure the recruitment of competent labour or provide the required training.

The quality and strength of materials was typically not known. Care should be taken to ensure the materials used are consistent with the design assumptions as outlined in the specifications. The labourers we spoke to confirmed that material checks and testing were not typically undertaken on site.

Construction drawings are not typically communicated appropriately for the level of capability and experience of the labourers and end users. This often led to the construction not being built as pre the design intent. This included critical seismic details not being built properly which undermined the durability of the building.

Poor quality construction was further compounded by the lack of appropriate quality assurance procedures. Site supervision by an appropriate technical expert is a good way to check quality of materials and workmanship and to advise on corrective action early to avoid having to carry out extensive remedial works and excessive maintenance further down the line.

Opportunity 5

There is an opportunity to improve the way in which design information is communicated to community builders through more engaging and understandable drawings and specifications. E.g. using 3D colour with simple explanatory text to illustrate good construction details and explain their importance.

Site Exposure

Site selection or physical planning of the school site does not appear to be undertaken. In the areas visited it was observed, and confirmed by the District Governments, that there was a shortage of suitable sites in many of the communities where schools are required. Land that is exposed to hazards, such as flooding or landslides, is often used for school buildings. Several of the schools visited during the field mission were disrupted by flooding and also had evidence of erosion around the foundations caused by water run-off. Three schools stated that flooding contributed to the loss of between 3 and 5 school days per month during the rainy season.

When the choice of sites is limited site appraisals should be carried out to identify key risks and where mitigation measures may be necessary to reduce the exposure to acceptable levels;

- Flooding can be mitigated by developing a drainage system for the site, collecting rainwater from the roofs and elevating the school building above the above the flood level.
- Landslides can be prevented by developing a drainage system and installing retaining walls or stabilising the slope to prevent erosion.

At many of the schools we visited, a lack of site planning in terms of building layout was observed. School buildings were often constructed very close to each other, or in one continuous long line. Buildings that are close together are susceptible to pounding during an earthquake.

<u>Opportunity 6</u>

The focus on Disaster Risk Management and safe building practices is on Earthquakes (and Tsunami) with limited information on planning and designing buildings for flooding. There is an opportunity to develop guidance for site selection, site assessment and mitigation measures through site planning to reduce the exposure of school building especially at risk to flooding and landslides.

4.4 Infrastructure Vulnerability Assessments

Vulnerability assessments were carried out on the schools visited in order to provide a quantitative analysis of the vulnerability of the different building typologies. FEMA 154[7] is an internationally recognised rapid visual assessment tool used to determine the vulnerability of buildings to earthquakes, and it was used in Indonesia to test whether it would be an appropriate assessment tool for planning a national retrofitting programme.

The assessments were (Appendix D3) were undertaken on at least one building in each of the schools visited. A score is assigned to each building to identify whether it is vulnerable to potential seismic hazards. Only three (15%) of the school buildings visited met the safety threshold (>2) that determines the seismic safety of the building. The construction typology of these three school buildings were the Concrete moment frame, timber haunched frame and light steel frame buildings. Buildings receiving a low score require further detailed evaluation, undertaken by a professional engineer with specific expertise in seismic design to the need for rehabilitation.

The results of the FEMA rapid visual assessment highlighted that confined masonry construction and unreinforced masonry construction are both vulnerable to seismic events. **Unreinforced masonry** construction should not be used in high earthquake zones because it is heavy and sensitive to movement which means it is damaged easily. FEMA 154 is based on the American Codes[8] which do not recognise **confined masonry** construction as a construction typology. To obtain a score for these buildings an “approximation method” was used which took an average of the final scores for the construction methodologies which most closely resemble confined masonry; reinforced masonry construction and concrete frame with unreinforced masonry infill. Furthermore, as the Indonesian Building Code[9] is a direct translation of the America Code ASCE 7-10[10] and does not recognise confined masonry construction, the FEMA assessment penalises the building for not being code compliant.

Generally all the unreinforced masonry and confined masonry buildings visited, which rely on full height shear wall panels to provide lateral resistance to earthquakes (and wind), were penalised further for having an irregular shape on plan. The maximum building width to length ratio 1:4 was typically exceeded and/ or the buildings had a lack of adequate stability system (e.g. shear wall panel) along the length of the building due to large window openings, refer to Figure 5.

---

[7] http://www.fema.gov/media-library-data/20130726-1646-20490-8071/fema_154.pdf
[8] American Society of Civil Engineers (ASCE)
[9] Indonesian Standards – Seismic Design for Buildings (SNI 1726:2012)
[10] Minimum Design Loads for Buildings and Other Structures (ASCE/ SEI 7-10)

Figure 5 Large window openings are typical and present a weakness for the stability of the building for masonry shear wall construction

Although not recognised by the American (and Indonesian) Codes, confined masonry can be a seismically resistant form of construction if detailed and constructed properly (e.g. it is recognised by Eurocode[11]). Due to the quantity of schools found to be constructed using confined masonry in Indonesia, FEMA 154 may not be the most appropriate rapid visual assessment tool to identify, catalogue, and prioritise buildings that are potentially vulnerable to seismic hazards.

UNESCO are currently developing a building vulnerability assessment tool (VISUS[12]) to characterise schools based on their construction typology. This includes site exposure, structural elements, non-structural elements (such as doors, chairs and cupboards) and functional issues (such as emergency access). It is intended to be used as a planning tool to prioritise which schools need interventions. It currently focusses on seismic hazards and it would be more useful as a multi-hazard evaluation tool. It seems to be very detailed and relies on expert judgement which may not be appropriate for a high level nationwide rapid vulnerability assessment of school infrastructure.

Opportunity 7

There is an opportunity to develop an appropriate rapid visual assessment method which is specific to the Indonesian context to identify, catalogue, and prioritise the vulnerability of school infrastructure to multiple hazards. There is an opportunity to review, test and adapt the VISUS tool to the Indonesian context to include multiple hazards, construction typologies and materials. This could provide a rapid visual assessment tool to compile a comprehensive GIS database of schools across Indonesia. This would enable schools to be ranked by vulnerability and prioritised accordingly for repair, retrofitting or reconstruction.

Opportunity 8

There is an opportunity to review and update the Indonesian Code to incorporate common construction typologies such as confined masonry.

[11] Eurocode 8: Design of structures for earthquake resistance (BS EN 1998)
[12] VISUS-Method Handbook V1.0, December 2013

4.5 Institutional Environment and Regulatory Framework

Five funding streams for delivering new school infrastructure and repairing damaged school infrastructure in Indonesia, have been identified;

1. MoEC National Funds
2. Special Allocation Fund (DAK) from Ministry of Finance (National)
3. Endowment Fund from Ministry of Finance (no evidence of schools hav8ing received money from this fund)
4. Provincial and District Level Funding
5. Ministry of Religious Affairs (National) Funds - provides religious education infrastructure centrally.

Refer to diagrams in Appendix F highlighting the responsibilities of different parties in each of the funding streams.

Responsibilities

School infrastructure is typically funded through the national government (except Option 4 above which is funded through local government). Typically the Education District Office highlights the need for new schools and proposes the school locations, which are then submitted to the MoEC for approval. The religious school needs and location are identified by the community and then funded by MoRA (Option 5).

Since the 1990s the MoEC government policy has shifted from a national school building program towards school managed construction. A school construction committee made up of teachers and parents, is designated as the Project Implementing Unit in the Government's budget execution system.. National funds (Option 1, 2 &5) are provided directly to a school construction committee, who are ultimately responsible for the procurement of a design consultant and contractor, and the delivery and maintenance of school infrastructure. The school construction committee typically appoints local labour directly as the budget provided often precludes the use of small contractors or results in buildings remaining unfinished. Whilst having a school construction committee creates community ownership there are challenges that arise when untrained people with little or no experience or knowledge find themselves in charge of construction management. This can lead to inefficient practices and inappropriate appointment of labour and a lack of understanding in dealing with issues.

Supervising consultants are hired by the school construction committee to oversee the quality of construction on site. However, the Public Works District Office is ultimately responsible for the quality of school infrastructure; they issue Building Permits prior to construction and Building Certificates on completion.

District officials appear to rotate roles regularly between different departments to reduce the risk of corruption. This results in people taking roles without the appropriate skills or qualifications. It also makes it difficult to retain knowledge and build capacity within the departments because experience is not shared and relationships are not developed.

Implementation Process

There are weaknesses in the implementation process of new school infrastructure (planning, design and construction) and assessing and repairing existing school infrastructure.

Planning and design

The building codes and regulations are provided and enforced by the Ministry of Public Works (MoPW), however there does not appear to be any planning regulations or approval process in place.

The BNPB has produced high level national education guidelines[13] that highlight the design requirements including that school buildings should be designed and built in accordance with the Indonesian Building Code (SNI 1726-2012). This is a robust Code, geared towards large buildings and can be overly complicated when applied to low-rise school buildings. The current 2012 seismic code has ~20% higher ground accelerations and more onerous detailing requirements than previous codes which means existing buildings designed to previous codes may no longer comply. It is unlikely that recent school buildings comply as most schools visited are construction using confined masonry (which isn't covered by this code), and during our interviews with key stakeholders it became apparent that the Building Code was not readily available and didn't appear to be enforced.

The MoEC have also produced model school designs which are generic across Indonesia and cover architectural requirements for school buildings. It is unclear whether engineering blueprints for model schools exist as they were not obtained during the field mission. Local consultants are responsible for adapting the model school designs to develop an engineered design in accordance with the national guidelines and local by-laws, to suit the local context. There was no evidence that local by-laws existed in districts visited which meant the design consultant has little guidance on hazards and materials relating to a specific area. Furthermore, the budget allowance for a new classroom is standard across the whole of the country and doesn't allow for a variation in costs to allow for more onerous requirements.

Opportunity 9

There is an opportunity to establish local by-laws that can be used to adapt the model school designs for the local context.

Approval

Public Works engineers are responsible for approving the designs, but they are not required to be professionally qualified. Professional qualification, through the National Association of Engineering Consultants (INKINDO), is benchmarked against other ASEAN countries and involves a thorough assessment process and regular refresher assessments. Public Works engineers may therefore lack the skills to carry out their responsibilities. Additionally, there is limited capacity in the Public Works District Office so detailed checks of building designs are not always carried out, especially for single storey buildings.

[13] Manual for Keeping Schools and Madrasahs Safe from Disasters, BNPB, 2012

ConstructionQuality assurance on site is ultimately the responsibility of the Public Works District Office, due to their lack of capacity they often rely on supervising consultants (who are not held accountable) to oversee quality and then sign off key stages of the works based on cursory checks and often in hindsight. Supervising consultants are not required to be degree qualified and can lack the understanding of safe school construction as it is not typically included in the curriculum for vocational schools.

Opportunity 10

There is an opportunity to develop a quality assurance methodology in the delivery of school infrastructure to clarify role and responsibilities and introduce checklists and audits. A suite of quality assurance tools and check lists will provide a clear understanding of what needs to be done, who is responsible, and a clear audit trail for all parties involved. This will improve quality of construction and reduce the opportunities for corruption.

Maintenance

The DAK fund is currently attempting to address the history of neglect to school infrastructure. A damage assessment can be carried out by the school to identify maintenance requirements which is verified by the District Office. The assessment is based on a percentage of damage to building elements which are weighted to give an overall percentage of damage for each classroom. These are categorised into light (<25% damage), medium (<45% damage), heavy (<65% damage) and total collapse (new classroom required). A budget is provided based the percentage of damage as a proportion of the cost of building a new classroom. This assessment methodology does not differentiate between superficial damage and structural damage and does not highlight the vulnerability of the building to future hazards. DAK funds are typically spent returning school buildings to their original condition, rather than strengthening or improving them to make them safer. The WB Safe School Pilot Program (refer to Section 4.6) aimed to improve safety through retrofitting and reconstruction. However there are no baseline criteria for retrofitting, it is unclear who is responsible for defining the scope of any retrofitting required or undertaken, and there is no evidence of guidelines for this.

Opportunity 11

There is an opportunity to review and improve the existing damage assessments to better understand the vulnerability of school infrastructure to natural hazards.

Opportunity 12

There is an opportunity to introduce safe school construction practices into the DAK program by providing a baseline criteria for repair and retrofitting works

4.6 Work By WB and Others

WB Safe School Pilot Project

In 2012, the World Bank undertook a Safe School Pilot Project[14] to provide facilitation, awareness, campaign and advocacy for 180 schools in three provinces utilising the DAK fund. This identified insufficient capability in the school construction committee and provided financial, social, and engineering facilitators to support the implementation. This facilitator model was based on the successful and well established National Program for Community Empowerment (PNPM) to support community managed rehabilitation of infrastructure.

The WB Safe School Pilot Project also introduced seismic safe school construction training into a vocational school in Lombok by training the teachers. The graduates and teachers of this course are now site supervision consultants to local school construction projects. This helps builds local capacity to improve quality assurance on site.

<u>Opportunity 13</u>

There is an opportunity to develop "training for trainers" on safe school construction that can be replicated at vocational schools nationally.

As part of this project the WB has produced a series of documents which include awareness of and preparedness for hazard events and simple guidance to assess the safety of school infrastructure[15]. This is well illustrated and includes some good seismic construction and retrofitting details for confined masonry. However, some aspects such as the building configuration and opening locations do not correspond to what was constructed at the pilot schools visited.

A practical guideline for school principals and school committees[16] has been developed using these documents. An Arup review of this document (Appendix G) highlights the importance to communicate appropriately to the target audience and to provide clarity of the purpose and intended use of the document.

AusAid

AusAid (now Department of Foreign Affairs and trade – DFAT) have provided technical assistance to the MoEC school building program for approximately 1200 schools since 2010. They are in the process of completing this technical assistance program and do not intend to continue. AusAid identified quality of design and construction as their key concern and centred their technical assistance on the provision of a quality assurance team.

AusAid developed a checklist and guidance[17] of information to be gathered of the proposed site for a new school. Whilst this is an important tool it does not appear to include guidance on how to interpret the information gathered to assess whether a site is appropriate or how to mitigate the risk from specific hazards. The visit to

[14] Safe School Pilot Project in Indonesia, Survey of Preliminary Impact and Recommendation, Tata Mustasya
[15] Amankah Sekolah Kita, GFDRR
[16] Making Schools Safe from Natural Disaster, WB Indonesia Task Team, 2014
[17] Verification Guidelines 2014, Australian Aid

AusAid School SMPN 4 Batang Anai, Padang, illustrated potential issues with their site selection due to evidence of foundation settlement and regular flooding.

They also developed thorough quality assurance checklists[18] containing well illustrated seismic construction details. This guidance appeared to be used exclusively on the AusAid supported schools but could also be used to improve the quality assurance at larger scale.

Consultants

Construction guidelines for single storey masonry housing to resist seismic hazards have been developed by Teddy Boen in partnership with local and international experts for both new construction[19] and retrofitting existing buildings[20]. These were provided by the MoPW as an example for safe school construction and whilst they contain well-presented best practice seismic construction details, they are not necessarily appropriate for use on school infrastructure. School buildings have a different configuration to residential buildings as they are typically large open plan rooms with few internal walls and therefore require different design considerations.

INGO's

PLAN International and Save the Children are involved in school safety initiatives targeting pillars two and three[21] – school disaster management and risk reduction and resilience education areas. Other NGOs and INGOs continue to be involved in education infrastructure in Indonesia, but the MoEC have indicated that their potential impact at scale is typically fairly limited.

<u>Opportunity 14</u>

There is an opportunity to review the existing documents that have been developed by various parties to produce specific guidance for the planning, design, construction of new schools and retrofitting of existing schools. These should be incorporated into the regulatory framework and enforced.

[18] Instrument Monitoring & Quality Checklist 2014, Australian Aid
[19] Membangun Rumah Tembokan Tahan Gempa, Teddy Boen & Rekan, 2005
[20] Perbaikan dan Perkuatan Bangunan Tembokan Sederhana, MoPW, 2012
[21] Comprehensive School Safety, UNISDR

5 Conclusions

There is a significant shortage of school classrooms and the demand for school places is increasing faster than the supply. This is compounded by lack of maintenance of school infrastructure and in many Districts damage to schools from previous disasters.

There is an increasing risk to school infrastructure due to the high exposure to hazards combined with the high vulnerability of both new and existing school buildings.

Existing schools that are in a state of disrepair or damaged are currently being addressed as part of the DAK Rehabilitation Program, but this currently does not reduce the vulnerability of existing schools. The various retrofitting guidance documents vary in quality and appropriateness, and they are not used widely because they are not included in the regulatory framework. There is an opportunity in the short term to integrate safety in to the existing DAK program by building on the work already undertaken by the WB Safe School Pilot Project.

The nature and extent of existing vulnerability of the 300,000 schools across Indonesia is currently unknown. A nationwide vulnerability assessment to assess the scale and extent of vulnerable schools by construction typology could inform both the prioritisation and type of intervention required to reduce the vulnerability of the Indonesia’s school stock at national scale.

There is an existing shortage of classrooms which needs to be addressed as well as building new schools to address the anticipated long term increase in demand for school places. When constructing new schools (for both temporary and permanent classrooms), it is important to avoid building in future vulnerability through inappropriate site selection, design, or poor quality construction.

There is a lack of detailed hazard information available for effective site selection and site planning. The Government model schools cover the architectural aspects only and are required to be engineered locally for each school. A lack of local b-laws has resulted in inappropriate designs that are not communicated effectively for the school managed construction teams. The Indonesian building code is a robust international code, but it does not recognise confined masonry, and it can be overly complex when applied to single story school buildings.

The fragmented policy / planning and building regulations associated with schools and implementing organisations has led to a lack of accountability and enforcement of quality controls on site. There is also a lack of capacity and expertise in the quality assurance process which has contributed to poor quality construction and vulnerability school infrastructure.

6 Recommendations for GPSS TA

In order to achieve a large scale solution which has a long term impact we recommend developing a **National Strategic Plan for Safe Schools** (NSPSS) which addresses the following;

- Existing schools;
  - in a state of repair or damaged from disasters and
  - those that are in good condition and
- New school construction

It is recommended that TA should be provided to;

1. **Review and improve the existing guidelines to develop retrofitting guidelines that are specific to the existing school construction typologies.** They should provide guidance on how to identify the type and extent of retrofitting required to reduce the risk to future hazards.
2. **Undertake damage and loss assessments and rapid visual vulnerability assessments to identify and prioritise the most vulnerable schools and whether they require repair, retrofitting or reconstruction to be able to design a comprehensive retrofitting program.** These assessments should be software based to enable an online GIS database to be populated. The new MoEC Revitalisation Pilot Programme may present an opportunity to trial the vulnerability assessments to identify the first 25 most vulnerable schools and test the retrofitting guidance information developed.
3. **Review and optimise the existing national school models and produce efficient, affordable and safe engineering blueprints that can be adaptable for each district and enforced through national and district regulations.** Guidance for new school construction should also cover site selection and planning guidelines, which include site assessment and site specific design to mitigate the risk of local hazards.
4. **Introduce improved quality assurance tools in to school construction, repair, and retrofitting implementation processes**. The fragmented policy / planning and building regulations associated with schools and implementing organisations should be streamlined by introducing quality assurance tools to improve the quality of construction on site and reduce the risk of corruption undermining the process. A clear delineation of responsibilities is required with quality checklists, audit processes, and local by-laws to enforce the use of model designs and retrofitting guidance material.
5. **Develop "training for training modules" that may include; repair, retrofitting, reconstruction and a variety of different construction typologies.** The capacity and capability of supervising consultants (and facilitators) should be developed by providing “training for trainers” on safe school construction. There is potential to collaborate with the National Association of Indonesian Engineering Consultants (INKINDO) and/or university institutions in providing the training and development of industry skills and capacity.

	Recomendations	Timeframe	Existing or New Schools		Opportunities
1	Review and improve the existing guidelines to develop standard approved repair and retrofitting guidelines that is specific to the existing school construction typologies.	Short Term	Existing Schools	14	Review existing guidance documents to produce specific guidance for the retrofitting of existing schools to be incorporated into the regulatory framework and enforced.
				12	Introduce safe school construction practices into the DAK program by providing a baseline criteria for repair and retrofitting works.
2	Undertake damage and loss assessments and rapid visual vulnerability assessments to identify and prioritise the most vulnerable schools and whether they require repair, retrofitting or reconstruction to be able to design a comprehensive retrofitting program.	Medium Term	Existing Schools	11	Review and improve the existing damage assessments to better understand the vulnerability of school infrastructure to natural hazards.
				7	Develop an appropriate rapid visual assessment methodology to identify, catalogue, and prioritise the vulnerability of school infrastructure to multiple hazards.
				3	Develop a retrofitting program to make existing school infrastructure safer to natural hazards, which could be piloted as part of the Government Revitalisation Pilot Program.
3	Review and optimise the existing national school models and produce efficient, affordable and safe engineering blueprints that can be adaptable for each district and enforced through national and district regulations.	Short Term	New Schools	1	Compile detailed hazard/ risk maps for each District to inform spatial planning and site selection.
				6	Develop guidance for site selection, site assessment and design mitigation measures through site planning to reduce the exposure of school building.
				2	Creative short term solutions to help address the classroom shortage challenge, such as shift operated classes, or the development of a model design for affordable and safe temporary classrooms.
				14	Review existing guidance documents to produce specific guidance for the planning, design, and construction of new schools to be incorporated into the regulatory framework and enforced.
				4	Develop engineered model school designs for different construction typologies to provide a consistent and safe set of construction details.
				5	Improve the way in which design information is communicated to community builders through more engaging and understandable drawings and specifications.
4	Introduce improved quality assurance tools in to school construction, repair, and retrofitting implementation processes.	Medium Term	Existing and New Schools	8	Review and update the Indonesian Code to incorporate common construction typologies such as confined masonry.
				9	Establish local by-laws that can be used to adapt the model school designs for the local context.
				10	Develop a quality assurance methodology in the delivery of school infrastructure to clarify role and responsibilities and introduce checklists and audits.
5	Develop "training for training modules" that may include; repair, retrofitting, reconstruction and a variety of different construction typologies.	Long Term	Existing and New Schools	13	Develop “training for trainers” on safe school construction that can be replicated at vocational schools nationally.

Appendix A

Document Register

ARUP **Incoming Document Register**

Job No. 238204-00

Discipline

Document Type

Sheet No.

Received From (Company Name)
World Bank and Partners

Project Title
GPSS - Support to Global Programme for Safer Schools Phase II Indonesia

Location Stored: https://projectsites.arup.com/id/768949/default.aspx?InitialTabId=Ribbon%2EDocument&VisibilityContext=WSSTabPersistence

Day
Month
Year

Document/Drawing Title & Filename	Doc No's.	Received From	Date Received	Doc description
Building Condition	1	World Bank	19/11/2014	MAPPING OF EDUCATION Madrasah Building Analysis (Sumatera-Java-Bali Island)
Final Draft Report - Survey of Preliminary Impact and Recommendation - Indonesia Safe School Pilot Project	2	World Bank	16/09/2014	Survey of preliminary impact and recommendation
Rehab Machanism	3	World Bank and Ministry of education and culture	19/11/2014	MECHANISM OF REHABILITION PROGRAM IMPLEMENTATION OF PRIMARY SCHOOL CLASSROOMS YEAR 2012
SD,MI dan SMP - Sekolah Aman3	4	World Bank	21/11/2014	Updated list of schools to visit with GPS coordinates
Safe School Proposal January 2014	5	World Bank	25/11/2014	Proposal for the program
Concept note School Rehabilitation and retrofitting30Des10	6	World Bank	27/11/2014	Concept note on incorporating resilience in school rehabilitation programmes
Presentation MoEC rev19June2014	7	World Bank	27/11/2014	Presentatino on lessons learned on Indonesia Safe School Implementation Pilar 1
Work Plan and Owner Estimate - School Retrofitting-revised	8	World Bank	27/11/2014	Ghant chart work plan and budget estimate for school retrofitting
Peraturan Menteri Pekerjann Umum	9	MoPW	Received in country	Blue Book in Bahasa - Technical Guidance for Buildings
Pedoman Penerapan Sekolah/Madrasah Aman Dari Bencana	10	BNPB	Received in country	Orange Book in Bahasa - Manual for keeping schools safe from disasters
Bersama Mewujudkan Sekolah Aman	11	World Bank	Received in country	White Book (GFDRR 2013) - in Bahasa, not translated
Gempa dan Tsunami	12	World Bank	Received in country	Illustratied pamphlet outlining tsunimai risks and preparedness (GFDRR) - in Bahasa, not translated
Sejarah Kebencanaan di Indonesia	13	World Bank	Received in country	Illustrated pamphlet highlighting natural disasters and response (GFDRR) - in Bahasa, not translated
Amankah Sekolah Kita	14	World Bank	Received in country	Illustrated guidelines containing hazard resistant construction guidance (GFDRR) - in Bahasa, not translated
Sekolah Aman Belajar Nyaman	15	World Bank	Received in country	Illustrated pamphlet promoting hazard awareness and preparedness (GFDRR) - in Bahasa, not translated
Materi animasi sekolah tahan gempa	16	Austrialian Aid	Received in country	Construction training DVD explaining good seismic construction details - in Bahasa, not translated
Apakah Anda Peduli	17	Austrialian Aid	Received in country	Illustrated pamphlets x 5 outlining hazard awareness, training, and construction details - in Bahasa, not translated
Form for Damage Level Analysis	18	World Bank	Received in country	Form for Damage Level Analysis - Damage Analysis Form for School Building or Class and Functional Room at school
Work Plan and Owner Estimate-School Retrofitting-revised	19	World Bank	Received in country	Updated work plan
Presentation MoEC.rev19June2014	20	MoEC	Received in country	Presentation
GPSS Safe school road map 2	21	World Bank	Received in country	Powerpoint which roadmaps the WB's plan for engagement for the safe schools programme
Presentation Consultant of Schools Pilot in Manila 30 Sept - 01 Oct 2013l	22	Dr Fauzan	Received in country	Presentation by Dr. Fauzan on GPSS in Indonesia
k32-39	23	World Bank	Received in country	Paper on the development of seismic hazard and risk maps for new seismic building and infrastructure codes in Indonesia
SNI 1726-2012	24	World Bank	Received in country	BSNI document in Bahasa. I think it is a code
MANUAL LIST OF CONTENTS	25	World Bank	01/12/2014	Contents page for a manual
MANUAL FOR KEEPING SCHOOLS MADRASAHS SAFE FROM DISASTERS 2012	26	World Bank	01/12/2014	Manual for keeping school safe from disasters
MANUEL CHAPTER 1 2012	27	World Bank	01/12/2014	Chapter 1 from the safe schools manual
MANUAL Annex 1 2012	28	World Bank	01/12/2014	Annex from the safe schools manual
Verification Guidelines - 2014	29	Austrialian Aid	01/12/2014	Guide documentation of verification by Australian Aid
School Profile USB- SMPN 4 Cipatat	30	Austrialian Aid	10/12/2014	Appears to be an assessment of a school
School Profile SATAP _SD Inpres Latondu	31	Austrialian Aid	10/12/2014	Appears to be an assessment of a school
img-141210105428	32	Austrialian Aid	10/12/2014	Appears to be an assessment of a school
img-141210105302	33	Austrialian Aid	10/12/2014	Appears to be an assessment of a school
Education Needs Assessment for Jakarta Floods	34	World Bank	Received in country	Education needs assessment for Indonesia
Austrialian Aid	35	Austrialian Aid	Received in country	Booklet Instrument Monitoring And Qulaity Checklist
Buku Panduan	36	MoPW	Received in country	MoPW guidelines for retrofitting single storey housing, 2012, coauthored by Teddy Boen
Membangun	37	Dr Fauzan	Received in country	Guidelines for single storey house seismic construction, 2005, Teddy Boen
2012-10-16_RIskmap_EQ_risk_assessment_2011	38	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia earthquake risk map
2012-10-16_RIskmap_Tsunami_risk_assessment_2011	39	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia tsunami risk map
2012-10-16_Riskmap_Vulcano_risk_assessment_2011	40	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia volcano risk map
2012-10-16_Riskmap_Flood_risk_assessment_2011	41	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia flood risk map
2012-10-16_Riskmap_Landslide_risk_assessment_2011	42	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia landslide risk map
2012-10-16_Riskmap_wave_risk_assessment_2011	43	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia wave risk map
2012-10-16_Hazardmap_Tsunami_risk_assessment_2011	44	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia tsunami hazard map
2012-10-16_Hazardmap_EQ_risk_assessment_2011	45	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia earthquake hazard map
2012-10-16_Hazardmap_wave_risk_assessment_2011	46	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia wave hazard map
2012-10-16_Hazardmap_Landslide_risk_assessment_2011	47	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia landslide hazard map
2012-10-16_Hazardmap_Flood_risk_assessment_2011	48	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia flood hazard map
2012-10-16_Hazardmap_Vulcano_risk_assessment_2011	49	http://geospasial.bnpb.go.id/?s=risk+map	27/11/2014	Indonesia vulcano hazard map
Earthquake Resistant Non-Engineered Construction	50	World Bank	09/01/2015	Guidelines for Earthquake Resistant Non-Engineered Construction, UNESCO coauthored by Teddy Boen
Making Schools Safe from Natural Disaster	51	World Bank	21/10/2014	WB Indonesia Safe School Pilot Programme - guidance for school management on implementing safe school practices

Appendix B

Hazard Desk Studies

B1 Geohazards Affecting Padang and Lombok

File Note

ARUP

13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

t +44 20 7636 1531
d +44 20 775Click here to enter extn

Project title	A summary of Geohazards affecting Padang and Lombok, Indonesia	Job number	238204-01
cc	Hayley Gryc Joseph Stables	File reference	
Prepared by	James Hollingsworth Katherine Coates	Date	18 December 2014
Subject			

A summary of Geohazards affecting Padang and Lombok, Indonesia

1 Tectonic Setting

Indonesia is a highly seismic country located in SE Asia, where the Indo-Australian plate collides with Eurasia (Sunda plate), forming a classic island-arc convergent setting. Indonesia is made up by over 17,000 islands (6,000 inhabited), many of which are volcanically active – a consequence of melt production as the Australian plate heats up with continued subduction of the Australian plate beneath the Sunda Plate. Indonesia has 127 active volcanoes, with some 5 million people having activities within the danger zone. The various islands forming the southern margin of Indonesia all lie within 200 km of the subduction megathrust, and are therefore prone to significant ground shaking from very large thrust earthquakes. Furthermore, vertical displacements of the sea floor during megathrust earthquakes can be large enough to generate devastating tsunamis, which have affected coastal settlements throughout recent and historical times. Land-sliding, and liquefaction, in response to earthquake-induced ground shaking, are also significant hazards throughout Indonesia; especially given that many settlements are located on floodplains comprised of soft sediments, and the weak volcanic ash-fall deposits are commonplace throughout the region. These problems are further exacerbated by Indonesia's tropical climate, characterized by heavy rainfall, which also creates additional flood hazard for low-lying communities.

We further summarize the various geo-hazards below for two separate locations in Indonesia: Padang City, on the island of Sumatra, and the western region of Lombok Island (Figure 1).

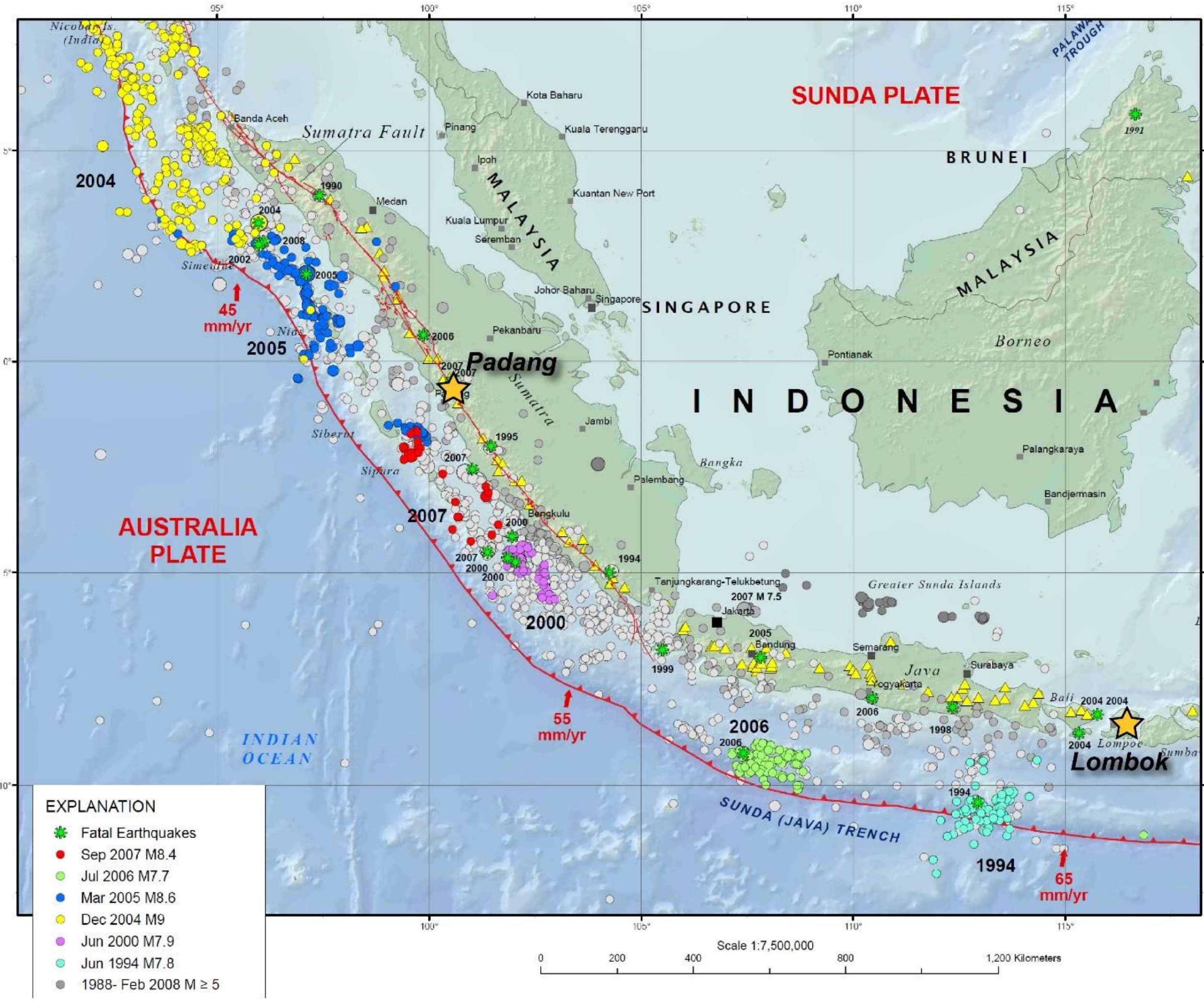


Figure 1 Tectonic setting of Padang (Sumatra Island) and Lombok Island within Indonesia.

2 Padang

2.1 Seismotectonics

Padang City (pop. 1 million) lies on the SE-coast of Sumatra (Figure 1), just over 200 km from the Sunda trench. The city lies on the west coast of Sumatra, on a strip of low-lying coast, made up of Quaternary sedimentary deposits laid down by rivers draining west from the Tertiary-Quaternary volcanic highlands (1 km high), which surround the city to the south and east.

The subducting Australian plate extends to depths of ~100 km beneath Padang city. Earthquakes are very common in this area, occurring on both the Sunda subduction zone interface (which accumulates 5.5 cm/yr elastic strain each year), and within the subducting slab itself.

On the 26th December 2004, a huge Mw 9.1 earthquake (max. fault flip 20 m) broke a 1,600 km section of the Sunda megathrust near Bandah Aceh, ~750 km NW of Padang (Figure 1). A few months later, on 29th March 2005, a second large Mw 8.6 earthquake (max. fault flip 12 m) ruptured the adjacent section of the subduction interface to the south, near Nias Island, ~450 km north of Padang. On the 12th September 2007, a Mw 8.5 earthquake (max. fault flip 8 m) ruptured the subduction interface offshore of Bengkulu, ~350 km south of Padang. An earlier Mw 7.9 earthquake occurred immediately south of the Bengkulu section on 4th June 2000 (see Figure 1 for summary of subduction interface earthquakes up to 2007). Therefore, a seismic gap exists between the Nias and Bengkulu segments of the subduction zone interface, offshore from Padang city. The last earthquake to break the Padang section of the Sunda megathrust occurred in 1797. Since this time, 181 years have elapsed, and ~10 m of elastic strain has accumulated on the locked fault zone, equivalent to a Mw 8.1 earthquake (based on a 200 km segment length, and fault scaling relations of [1]). Furthermore, the 2005 and 2007 events will have further loaded this segment with stress, edging it closer to failure. A large earthquake on this fault is therefore expected, and could occur at any time.

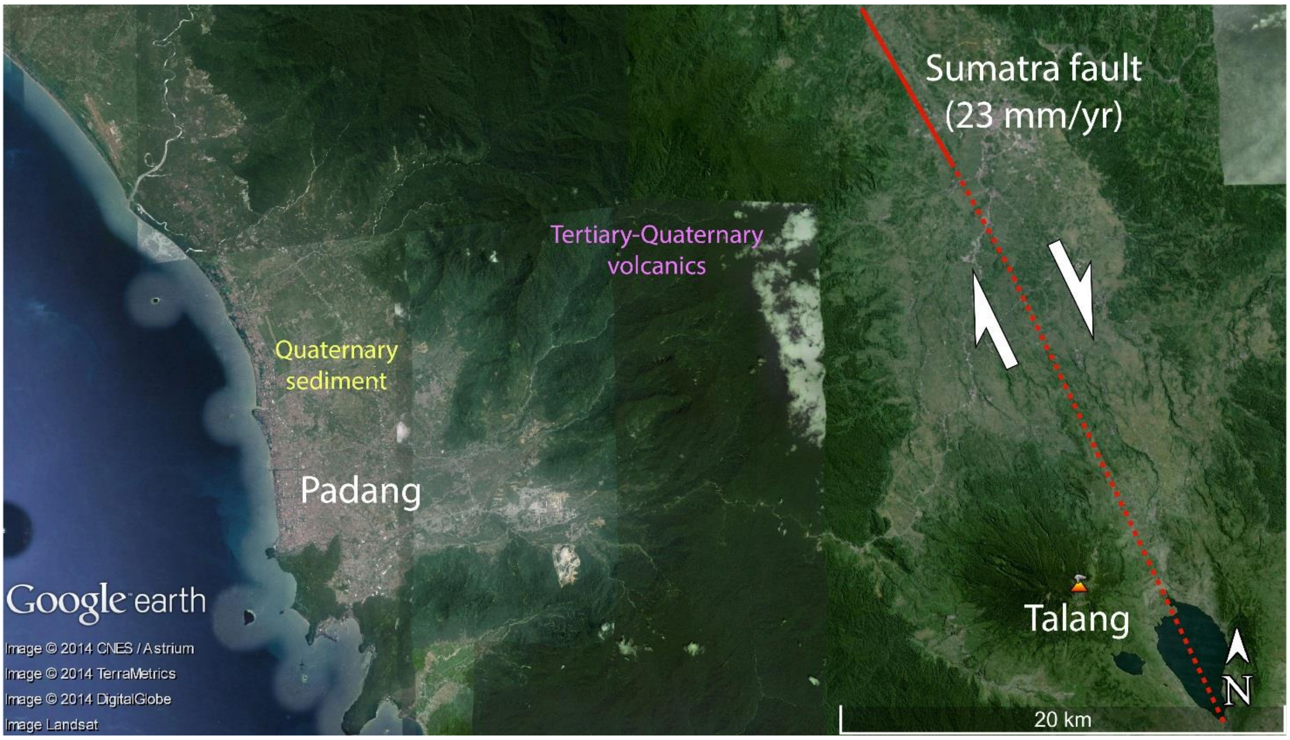


Figure 2 Location map of Padang City.

On 30th September 2009, a Mw 7.5 earthquake broke the subducting Australian plate ~50 km NW of Padang. The deeper source for this event indicates it was an intraplate event, with slip on a pre-existing fault within the subducting slab, rather than rupturing the subduction zone interface. In general, the largest intraplate earthquakes in subducting slabs are much smaller (Mw < 7.8) than the largest earthquakes on subduction zone interfaces (which can reach Mw 9.2). Furthermore, subduction intraplate earthquakes are typically deeper than subduction zone interface earthquakes. Therefore, the damage resulting from the 2009 earthquake was significantly less than for the 2004 Sumatra-Andaman earthquake (in large part because the earthquake did not produce a tsunami). Nevertheless, due to the close-proximity of the epicentre to Padang, widespread structural damage occurred in the city from ground shaking, liquefaction and land-sliding, resulting in 1,195 deaths, and significant damage to 140,000 homes and 4,000 other buildings [2]. Figure 2 shows the recent and historical earthquakes occurring in the Padang region.

An additional earthquake hazard posed to Padang City comes from the Great Sumatran fault, which is a major NW-SE striking strike-slip fault running along the SE margin of Sumatra (Figure 2 and

Figure 3). The oblique NNE convergence direction of the Indo-Australian plate with respect to the Sunda megathrust has resulted in partitioning of displacement onto separate thrust and strike-slip faults. This fault bears many similarities to the San Andreas Fault in the western US both in dimension (~1,500 km long), slip-style (right-lateral strike-slip) and slip-rate (~23 mm/yr). The Great Sumatran fault lies only 20 km east of Padang city, and therefore poses a major ground shaking hazard in the event of a large earthquake. This fault has experienced no very large earthquakes (Mw > 7.0) in recent times, although several Mw 6-7 events are known along its length. Compared to the San Andreas Fault, relatively little is known about the historical seismicity on the Great Sumatran fault.

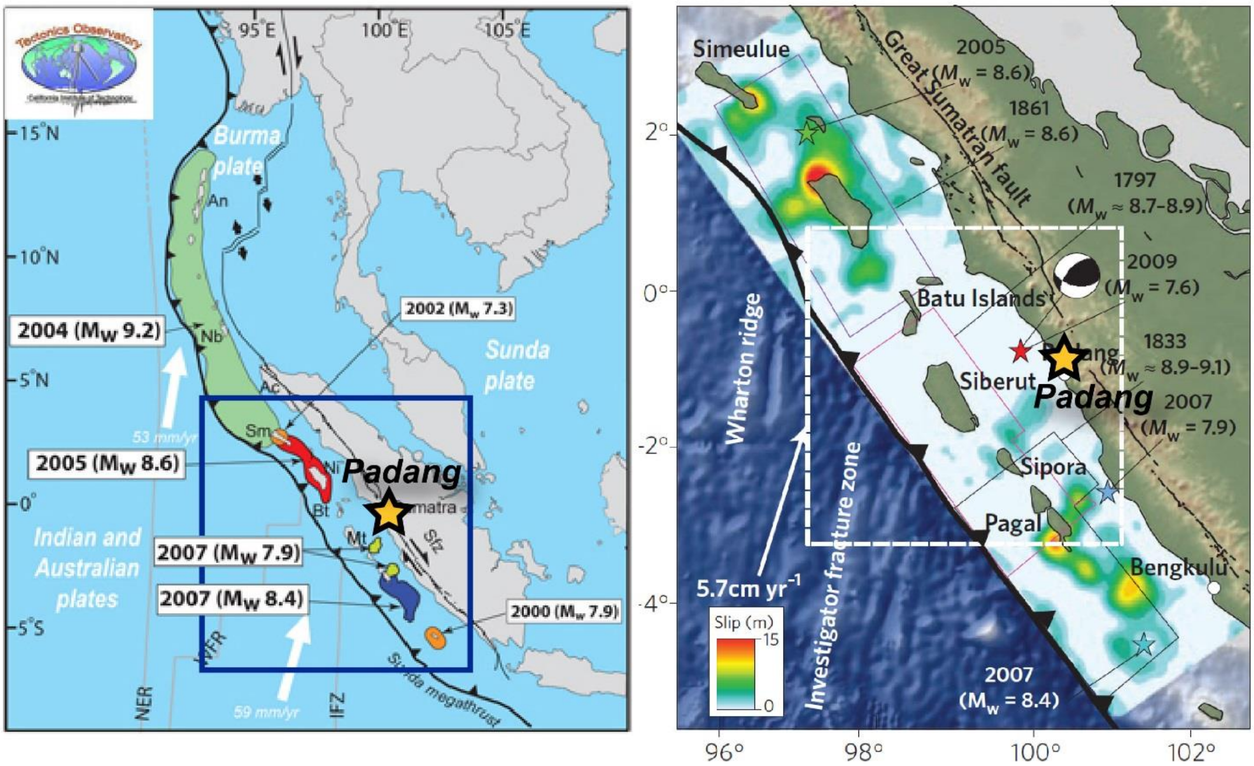


Figure 3 (left) Tectonic map of Sumatra, with locations of recent earthquakes and their respective fault slip patches (from Tectonic Observatory, Caltech). (right) map of the Padang region with recent and historic earthquake rupture locations. Black focal mechanism is for the 2009 Padang earthquake (from [3]).

2.2 Volcanic Hazard

Talang is the closest volcano to Padang, lying ~30 km east of the city. Talang is an active strato-volcano, capable of periodic explosive and effusive eruptions (Figure 1). The Smithsonian Institution Global Volcanism Program reports eight confirmed eruptions between 1833 and 1968. All historical eruptions have involved small-to-moderate explosive activity from craters on the NE flank. It is thought an eruption in April 2005 was triggered by the 2004 earthquake.

Although Padang is not in direct danger of erupted material, or pyroclastic flows from the flanks of Talang, a hazard may exist for any buildings with inadequate strength to support heavy loads of ash-fall, which can be significant at distances of 30 km.

Figure 4 shows the volcano risk map for the Padang region, produced by BNPB. Padang city is classified as low risk, although it lies adjacent to a high risk zone immediately to the east.

File Note

238204-01 18 December 2014

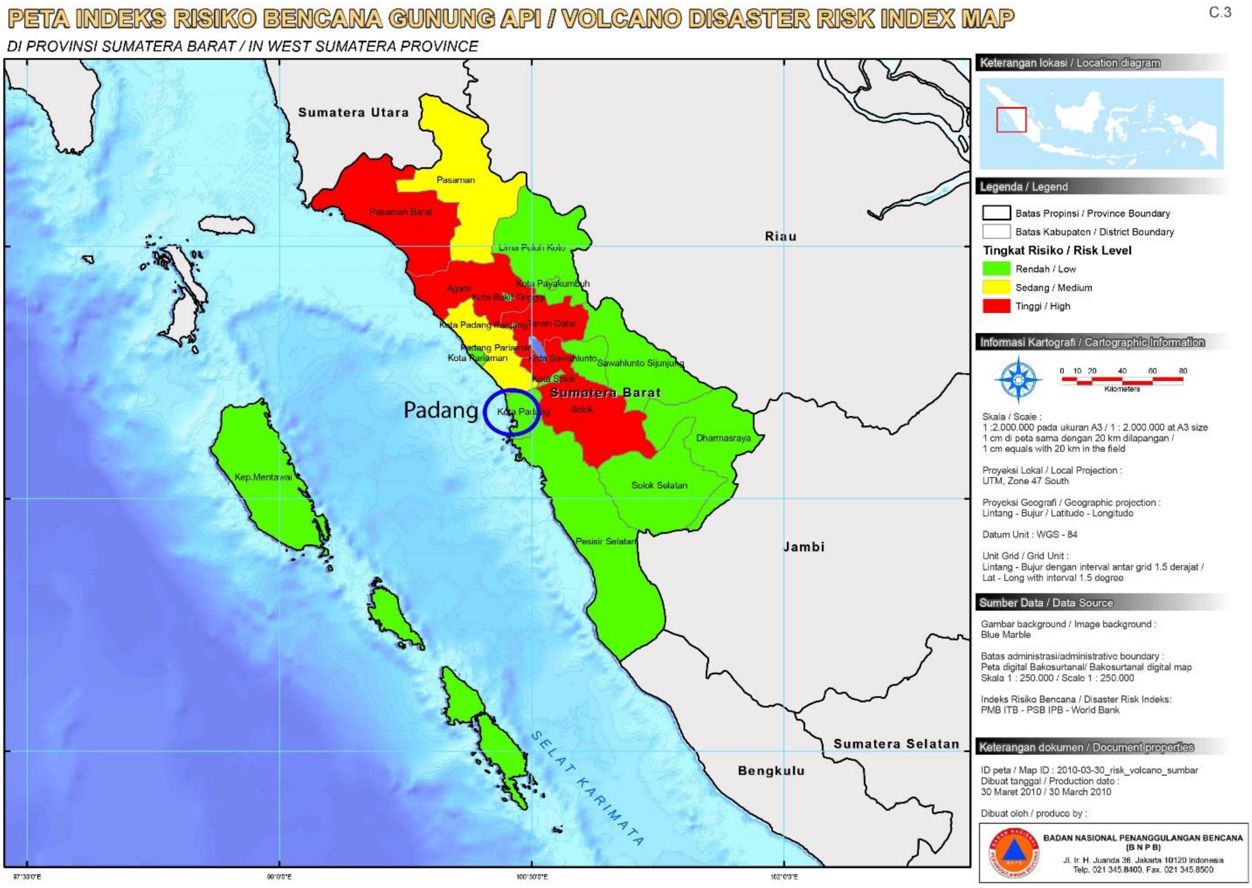


Figure 4 Volcanic disaster risk map, published by the Badan Nasional Penanggulangan Bencan (BNPB). Padang is in a low risk zone, which is bounded on its eastern side by a high risk zone (where Mt Talang is located).

2.3 Tsunami hazard

The Sumatra coast is at high risk from tsunamis generated offshore by slip on the Sunda megathrust, which in turn produces large vertical displacements of the sea floor in the offshore region. The slip gap offshore from Padang city is currently loaded, and will likely generate a large earthquake in the near future. The last subduction zone interface earthquake to affect Padang city occurred in 1797. Simulation of ground motions for this earthquake may give an indication of possible wave heights for future tsunamis affecting Padang (Figure 5, see also [4], [5]). Wave heights may reach up to ~6 m in height, which could inundate the coast by 4 km in the northern part of the city. Tsunami hazard is highest towards the coastline, and along river banks. High ground to the south and east of the city offers protection during a tsunami. However, the evacuation times from the worst tsunami-affected areas in NW Padang are significant (>40 minutes), while access to the high-ground south of the city is limited by bridges crossing the river Arau.

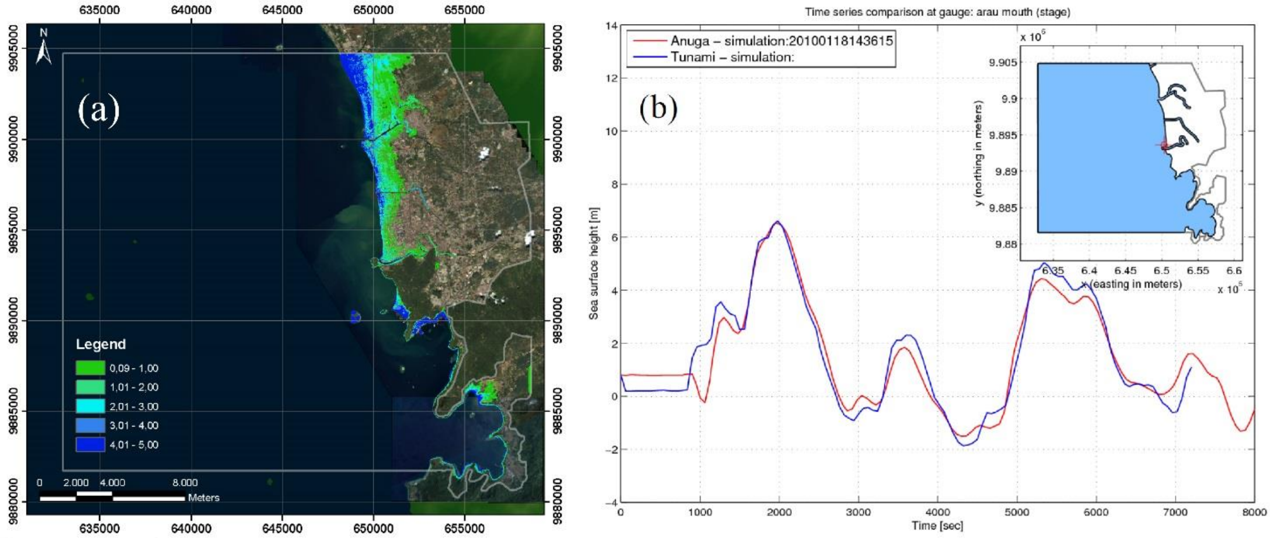


Figure 5 (a) Maximum simulated inundation map for Padang city (from scenario SID-08 of [5]). (b) Water level time history for the river mouth of the Arau River.

2.4 Liquefaction

Padang was badly affected by liquefaction during the 2009 earthquake. Loose sandy soils coupled with a shallow water table characterize the sub-surface on which Padang is built. Figure 6 shows a liquefaction susceptibility map for Padang city [6].

2.5 Slope failure, mud and debris flows

In the 2009 earthquake, slope failures caused extensive damage of roads in the mountainous region east of Padang city. Slope failures in the loosely packed volcanic ash deposits were initiated by ground shaking associated with the earthquake, and further enhanced by the high water content of the deposits, their lack of cohesive force, and the dip of bedding towards the slope direction (Aydan, 2009). Figure 7 shows damage to roads in Padang Alai. Some damage also occurred to roadways resulting from rock falls; blocks more than 5 m in diameter were observed along the Padang-Bukittinggi Highway and Padang-Bungus [7].

Northeast of Padang and east of Pariaman city, hundreds of people were buried by landslides and mud flows in Lubuk Lawe village, and at least five other villages were demolished [8].

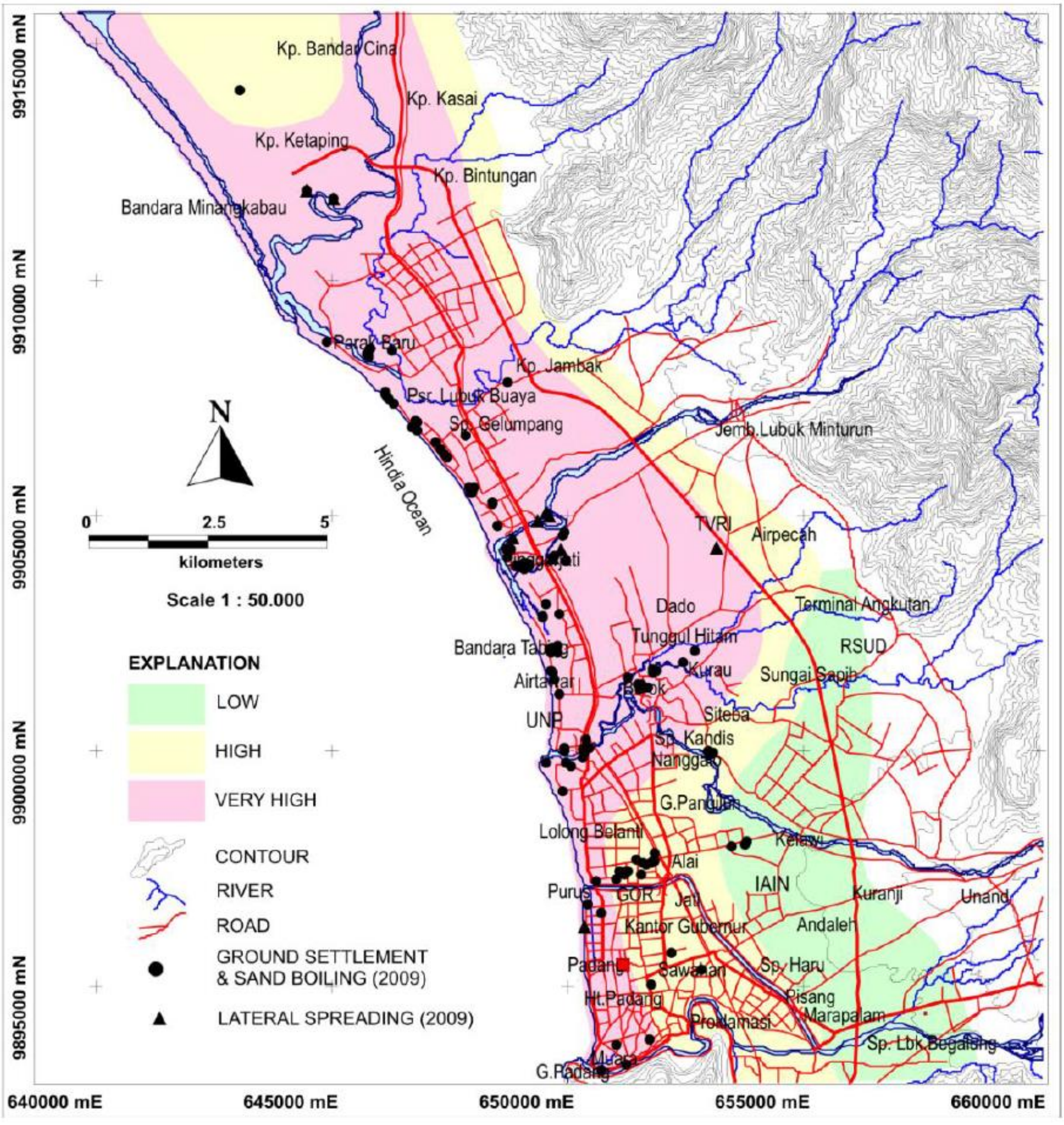


Figure 6 Liquefaction susceptibility map of Padang City [6].

Figure 7 Roadway damage due to slope failures in Padang Alai (on the southern margins of Maninjau caldera, ~30 NNE of Padang city), from [7].

3 Lombok

3.1 Seismotectonics

In comparison with Padang, Lombok Island has experienced few destructive earthquakes in recent times. Nevertheless, Lombok is also located on an ocean island overlying the Sunda subduction zone, which therefore presents a major seismic hazard to the island. The last significant earthquake to rupture the Sunda subduction zone interface in this region occurred on 2nd June 1994 (Mw 7.2), which the subduction megathrust south of East Java (400 km SW of Lombok, see Fig. 1). An earlier earthquake also broke the megathrust 380 km SE of Lombok on the 19th August 1977 (Mw 7.9). No earthquakes larger than M7.0 have been recorded on this section of the Sunda subduction zone over the last 50-100 years. Therefore, a seismic gap may exist on the subduction megathrust immediately south of Lombok Island.

Little is known regarding the historical record of seismicity in this region of Indonesia. The only significant event in the area is the 20th January 1917 Bali earthquake, which killed 1,500 people on the neighbouring island of Bali. Ground shaking was strongly felt in western Lombok. This event produced a small tsunami, which did little damage. Therefore, it is likely this earthquake did not break the Sunda megathrust.

Figure 8 shows significant earthquakes occurring on or nearby Lombok Island. Several medium-sized earthquakes have occurred on the island, ranging in magnitude from M5.1 to M5.3. Events of this size are typically not damaging, doe to their small ground motions. Several larger earthquakes occurred offshore of NW Lombok in 1979 (ranging from M6.1 to M6.3). In total, about 70 people were killed in these events, with widespread damage in NW Lombok. A damaging earthquake also occurred offshore NW Lombok on 22nd June 2013. Despite being a relatively small event (Mw 5.1), nearly 2,000 houses old brick buildings constructed on soft soil were severely damaged.

The convergence rate along the Sunda arc at the longitude of Lombok is ~6.5 cm/yr. There have been no major earthquakes on this section of the subduction megathrust for at least 100 years. During this time, ~6.5 m of elastic strain has accumulated on the locked fault zone. If a 200 km segment of the megathrust broke by 6.5 m, this would corresponding to a Mw 7.1 earthquake. An earthquake of this size could be damaging to Lombok island communities, both from ground shaking and tsunami inundation.

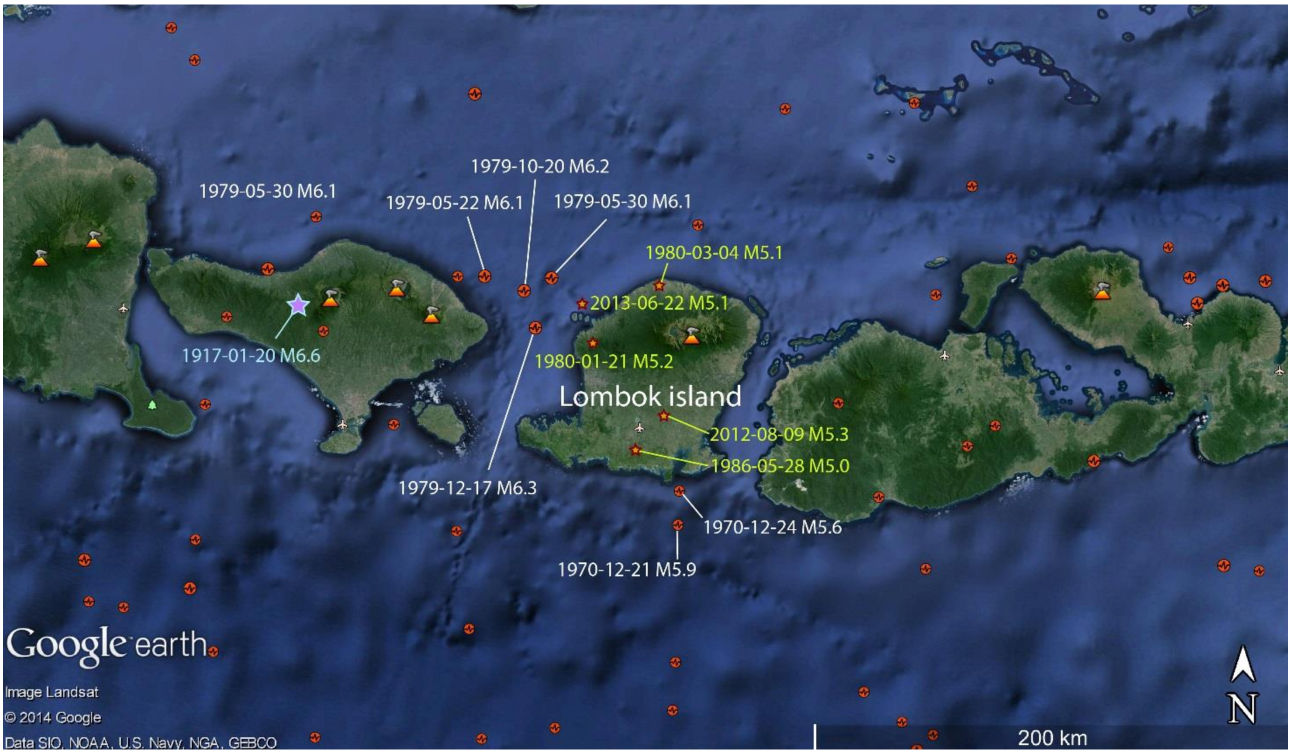


Figure 8 Seismicity of Lombok Island.

3.2 Volcanic Hazard

Lombok is dominated by a large strato-volcano, Rinjani, which rises to 3726 m elevation (second highest volcano in Indonesia). Atop Mount Rinjani, sits a 6 x 8.5 km caldera which has partially filled with water to produce a crater lake, known as Segara Anak. Mount Rinjani is thought to have erupted in a huge caldera-forming eruption in 1257AD, which may have triggered the Little Ice Age global cooling event. Figure 9 shows the suspected pyroclastic flow paths for the 1257 eruption [9].

File Note

238204-01 18 December 2014

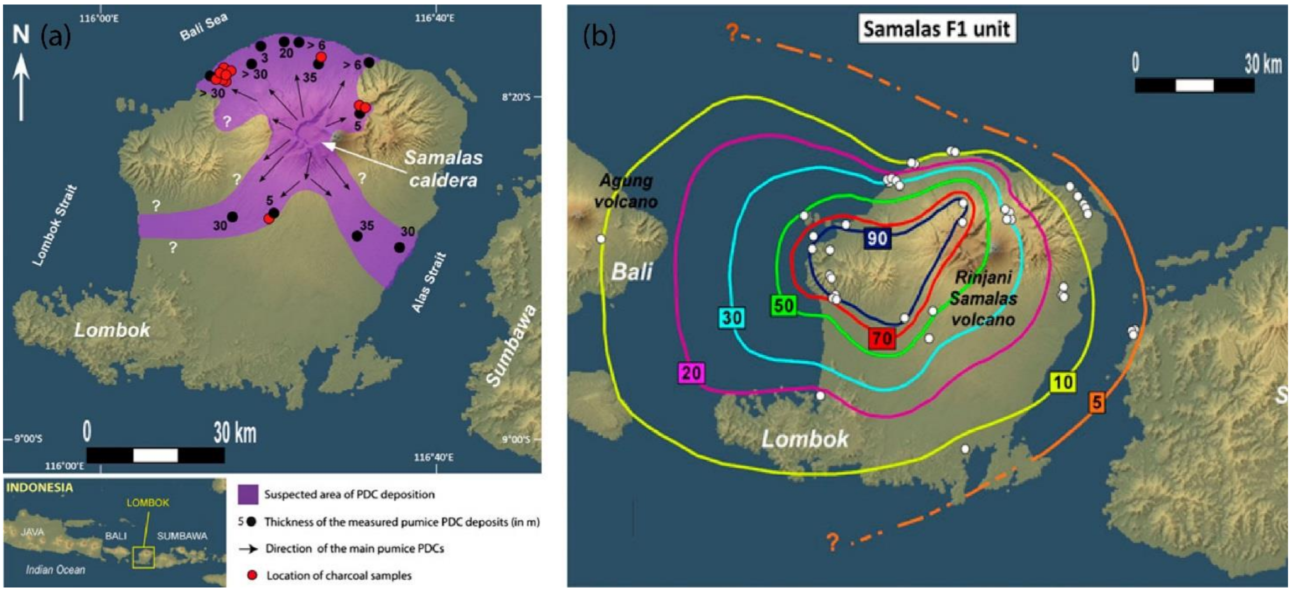


Figure 9 Map showing (a) the pyroclastic flow paths, and (b) contours of ash-fall thickness (cm) during the 1257 Rinjani eruption.

Rinjani has continued to be active since the mid-19th century. In November 1994, cold lahars (volcanic mudflow) killed 30 people in Aikmel village, following activity of Ranjani (rated 3 on the Volcanic Explosivity Index, VEI). The most recent activity occurred in May 2010, although no casualties were reported.

Figure 10 shows the volcanic hazard map for Lombok Island. Both North and West Lombok are classified as medium risk. The high ground area of SW Lombok may be relatively protected from pyroclastic, lava and mud flows originating from Ranjani caldera. However, Lombok's largest city of Mataram (in western Lombok) lies directly in the south-eastern flow path of the 1257 pyroclastic flow.

3.3 Tsunami hazard

Lombok is susceptible to major tsunami hazard resulting from slip on the Sunda megathrust to the south. Although southern Lombok coastline lies closest to the Sunda trench, the hilly topography coupled with the relatively low population density in this part of the island help to reduce the hazard. According to the 2011 Tsunami Risk Map, produced by BNPB (National Agency for Disaster Management), the regions at most risk from tsunamis are SW Lombok (cities of Lembar and Geroeng), and NE Lombok (cities: Lepeloang and Soengian; islands: Pulau Lawang and Lulau Sulat), see Figure 11. Various other risk maps produced by BNPB are also shown ("risk" incorporates the vulnerability and ability of a region/city to recover and the frequency (probability) of a hazard occurring).

File Note

238204-01 18 December 2014

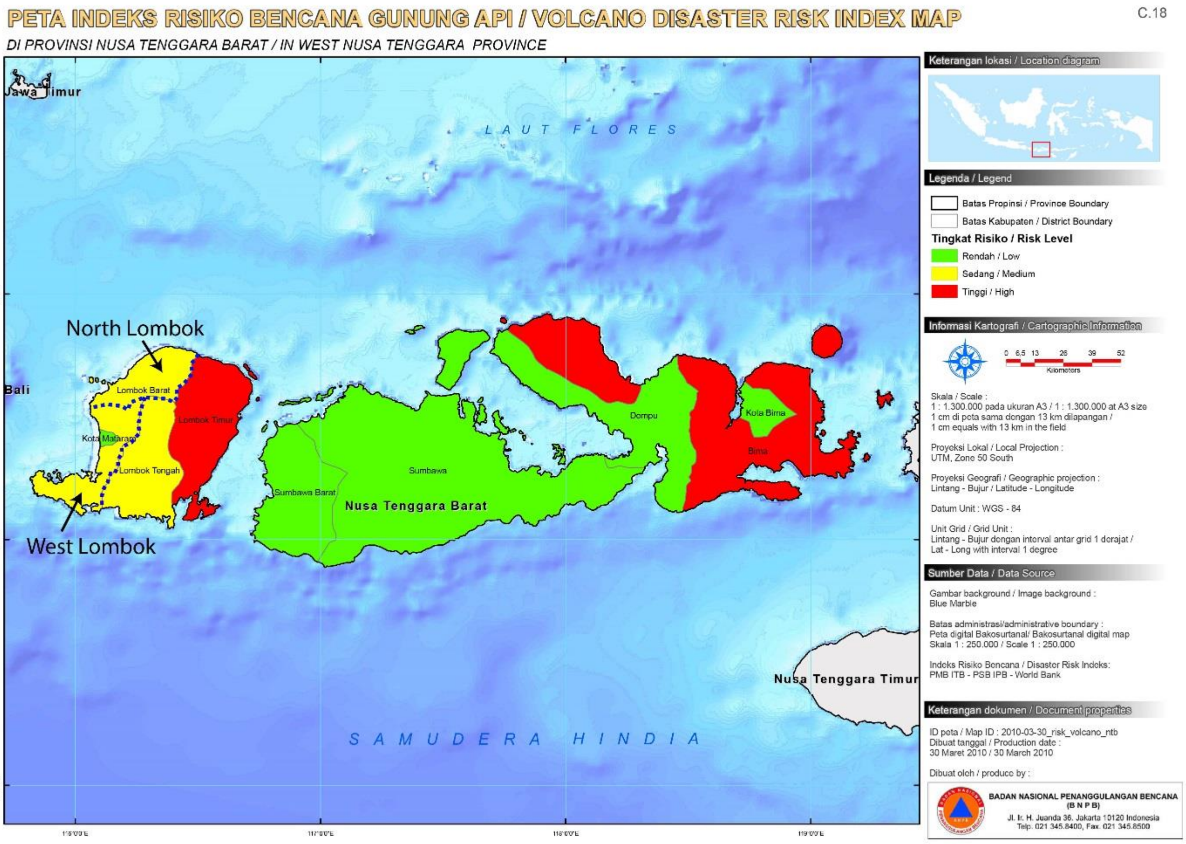


Figure 10 Volcanic hazard map for Lombok Island.

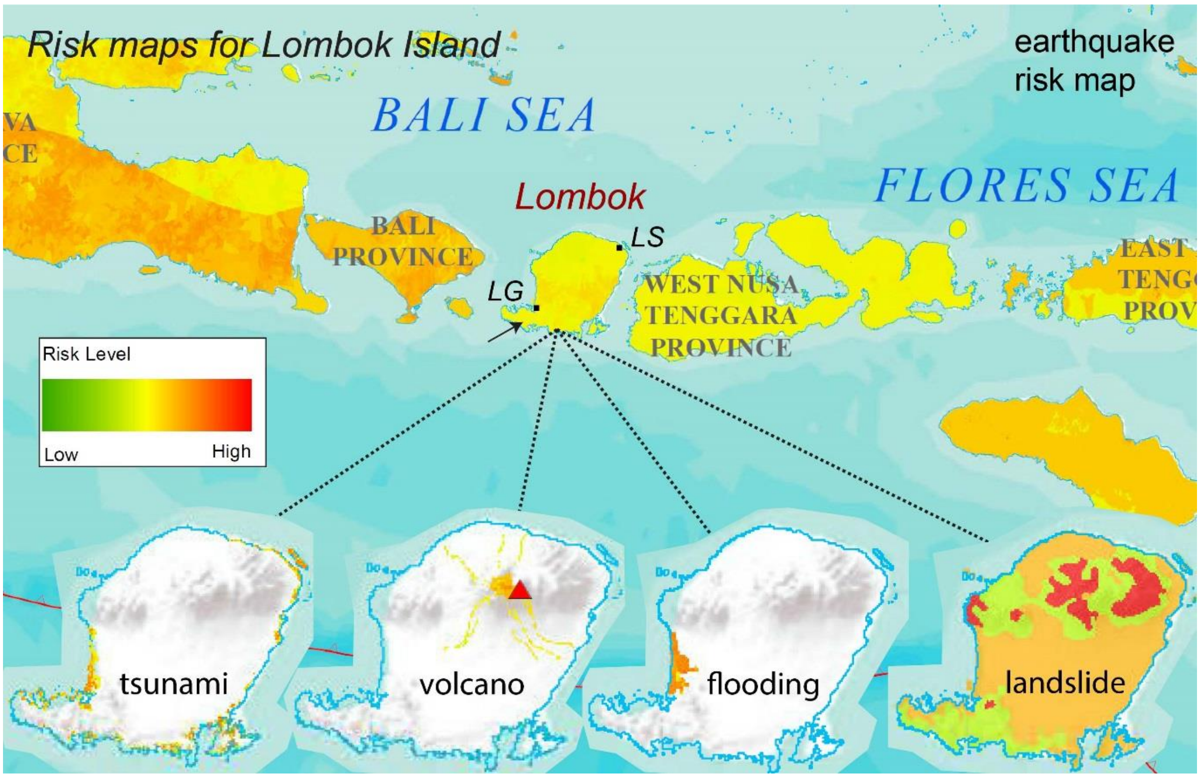


Figure 11 Regional risk maps for Lombok Island, including tsunami, earthquake, volcano, flooding and landslide (from Geospasial BNPD). Cities: LG: Lembar and Geroeng, LS: Lepeloang and Soengian.

3.4 Landsliding and liquefaction

Much like Padang, parts of Lombok Island are at high risk from landslides and liquefaction. High topographic gradients (especially around Mount Ranjani - see Figure 11), coupled with extensive ash-fall deposits and heavy rainfall all contribute to increased landslide hazard. Furthermore, illegal mining and deforestation also contribute to destabilising hillsides, and have contributed to landslide fatalities in SW Lombok in 2009 (http://www.landslideblog.org/2009/01/landslide-in-lombok-indonesia.html).

Less is known on the liquefaction potential of North and West Lombok. However, liquefaction is likely to present a significant hazard to communities built on low lying flood plain and coastal areas such as the west Lombok coastline, stretching from Lembar city in the south to Mataram city in the north.

4 Seismic design

The Indonesian Seismic Design Code (SNI 03-1726-2002) was first introduced in 2002, and was prepared in accordance with the 1997 Uniform Building Code (UBC, 1997). An update to the code took place in 2010, incorporating additional data and knowledge acquired after the 2004 earthquake, and the 2009 International Building Code. **Error! Reference source not found.** shows the PGA hazard map for Indonesia (PGA: 1% exceedance in 50 years, i.e 4975 year return period; 0.2 s and 1.0 s: 2% exceedance in 50 years, i.e. 2475 year return period), and Table 1 summarizes the hazard for both Padang and North and West Lombok.

Location	**Source**	**4975 yr return period**	**2475 yr return period**	
		PGA [g]	**0.2 s [g]**	**1.0 s [g]**
Padang	2010 update of the SN1-1726 Hazard Map	0.5-0.6	1.2-1.5	0.5-0.6
North Lombok		0.4-0.5	1.0-1.2	0.3-0.4
West Lombok		0.4-0.5	0.9-1.0	0.4-0.5

Table 1 Summary of hazard values for rock sites according to SNI-2010.

File Note

238204-01 18 December 2014

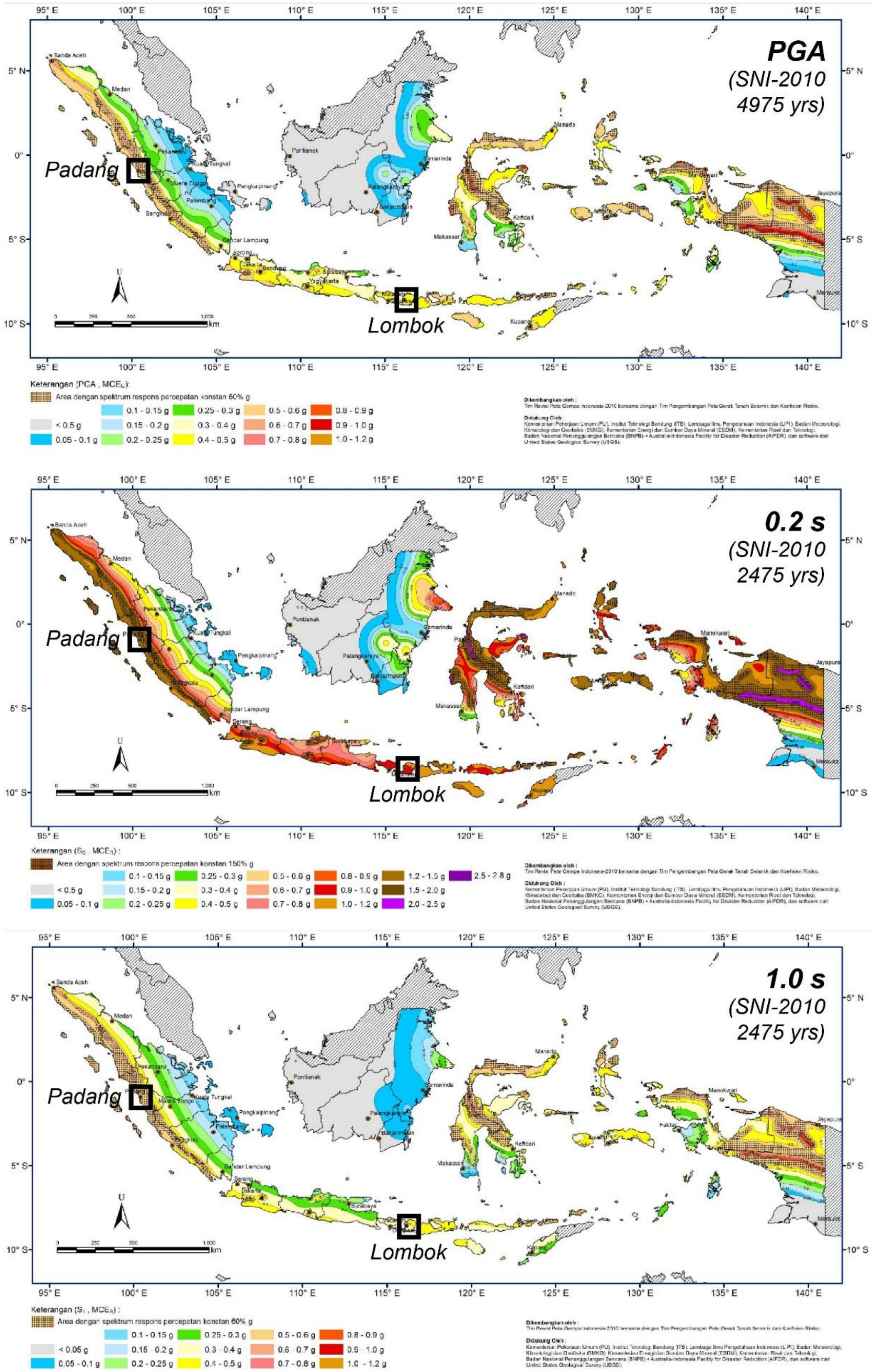


Figure 12 Hazard Map from the 2010 Indonesian code revision. Values are PGA, 0.1 s and 1.0 s spectral accelerations for a 475 return period.

4.1 Padang

Padang city lies on a flood plain, composed of soft and water saturated sand and alluvium. Based on the global USGS VS30 dataset (which is based on topographic slope angle, rather than geophysical measurements of shear-wave velocity in the top 30 m of the surface), Padang city is mostly located on class D material, based on both the SNI-2010 code and ASCE 7-05 (which uses Ss and S1 values from Petersen, et al., 2007), see Figure 13 (in the earlier version of SNI-2002, site class D is equivalent to “medium”). The USGS VS30 dataset indicates the eastern limit of the city, which abuts the high topography, is site class C in SNI-2010 and ASCE 7-05 (or “hard” in SNI-2002). However, given the bedrock geology is composed of mechanically weak ash-fall deposits, it may be better represented by site class D. The resulting design response spectra are shown in Figure 14.

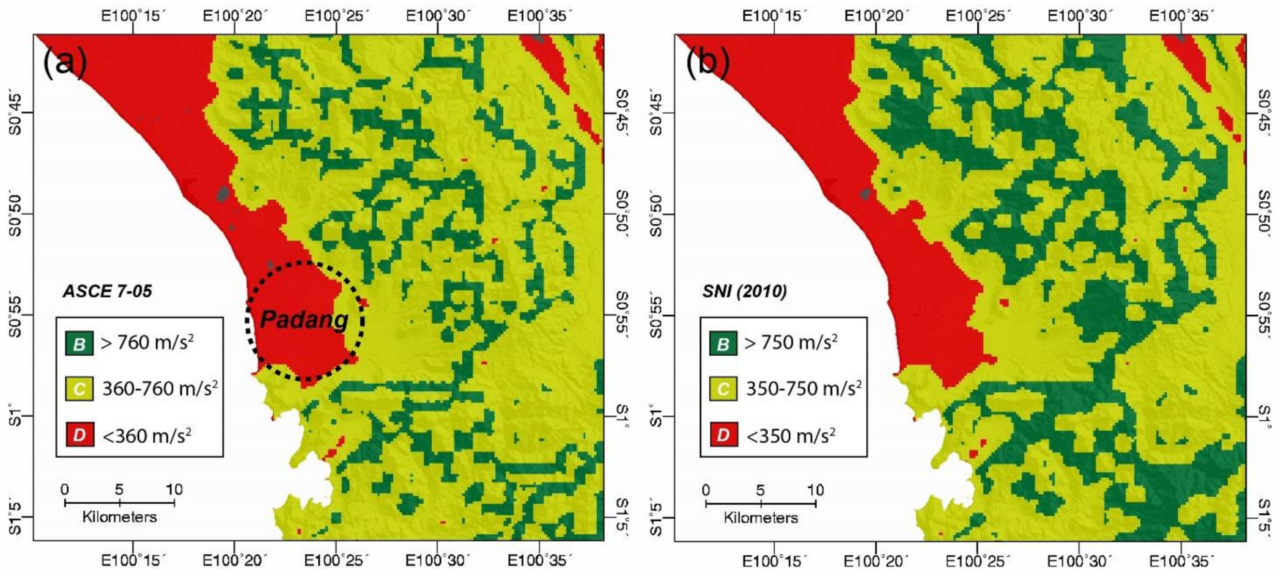


Figure 13 Site classification, according to (a) ASCE 7-05, and (b) 2010 Indonesian Seismic Design Code for Padang City.

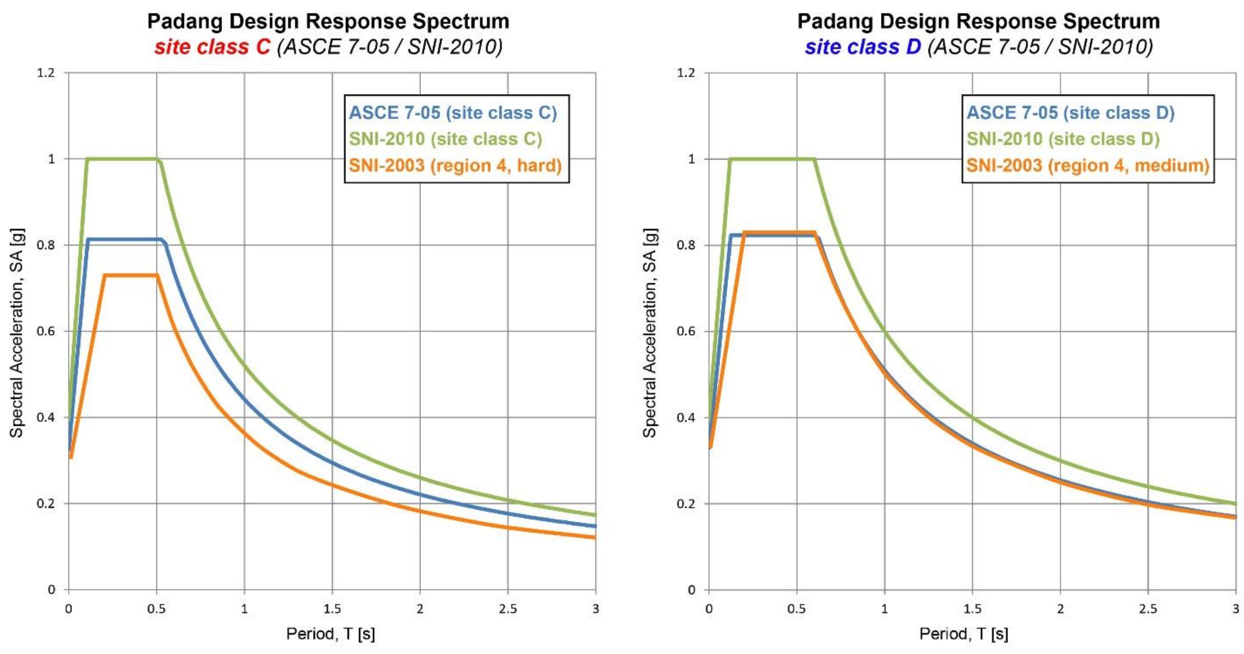


Figure 14 ASCE 7-05 and SNI (2010) design response spectra (site class C and D) for Padang city.

The typical construction of Padang city in the aftermath of the 2009 earthquake is described in [8]. The authors' state:

"*Most multi-story buildings in Padang are reinforced concrete frames with unreinforced solida clay brick infill walls. The frames are designed as the primary lateral force-resisting system; the stiffness and strength from the brick infill walls are not typically considered in design.*

Story collapses, often in the first story, were observed in many buildings. These were due primarily to a combination of weak columns, strength and stiffness irregularities created by discontinuous or failed infill walls, and deficiencies in concrete reinforcement detailing and construction. Collapses were more prevalent in concrete buildings constructed prior to about 2002, before Indonesia revised its building codes with higher seismic base shears and more stringent design requirements. Particularly in older buildings, the concrete frame member sizes appeared smaller than required to resist the ground motion demands. In such cases, the infill walls tended to improve the performance initially, up to the point that the walls failed, then led to a concentration of deformations that could cause collapse.

Deficiencies observed are similar to those seen in older reinforced concrete buildings in the United States and in developing regions throughout the world. Concrete spalling and failure revealed (a) absence of column stirrups in beam-column joints, (b) use of plane, as opposed to deformed, reinforcing bars, (c) insufficient column ties (large spacing, small diameter) with 90 degree hooks with minimal overlap, and (d) concrete with rounded river stone aggregates and low bond/compressive strengths. Beyond the structural system, infill walls and other architectural finishes (drywall partitions, glass facades, plaster coatings) were damaged extensively by the deformations of the flexible concrete frames."

The authors also highlight problems in Padang city with enforcement of building codes, particularly for smaller buildings and renovations, which are often not reviewed by city building department officials.

4.2 North and West Lombok

The province of North Lombok lies mostly on the flanks of Mount Rinjani, and therefore is likely to be closer to bedrock than populations in the flat flood plains along on the southern foot of Rinjani. The USGS VS30 dataset indicates site class C (SNI-2010, ASCE 7-05), or "hard" (SNI-2002) for North Lombok, except along a thin coastal strip, which is better presented by class D (SNI-2010, ASCE 7-05) or "medium" (SNI-2002) – see Figure 15. West Lombok spans a wide region covering the southern flanks of Rinjani in the north, to the flat lowlands in the centre, and the rugged medium-high topography of the south-west corner of Lombok. The main population centre, Mataram city, is located on the flood plain in West Lombok, which is of soft and water saturated sand and alluvium. The USGS VS30 dataset indicates site class D (SNI-2010, ASCE 7-05) for this region (or class "medium" in SNI-2002). Where the topography increases to the south, the site class increases to stiffer soil, and is better represented by site class C. However, given that mechanically weak ash-fall deposits are common throughout the area, more detailed VS30 measurements would be recommended to better determine the site class for specific sites throughout Lombok. The resulting design response spectra for site classes C and D, and their comparison with the older SNI-2002 building code are given in Figure 16.

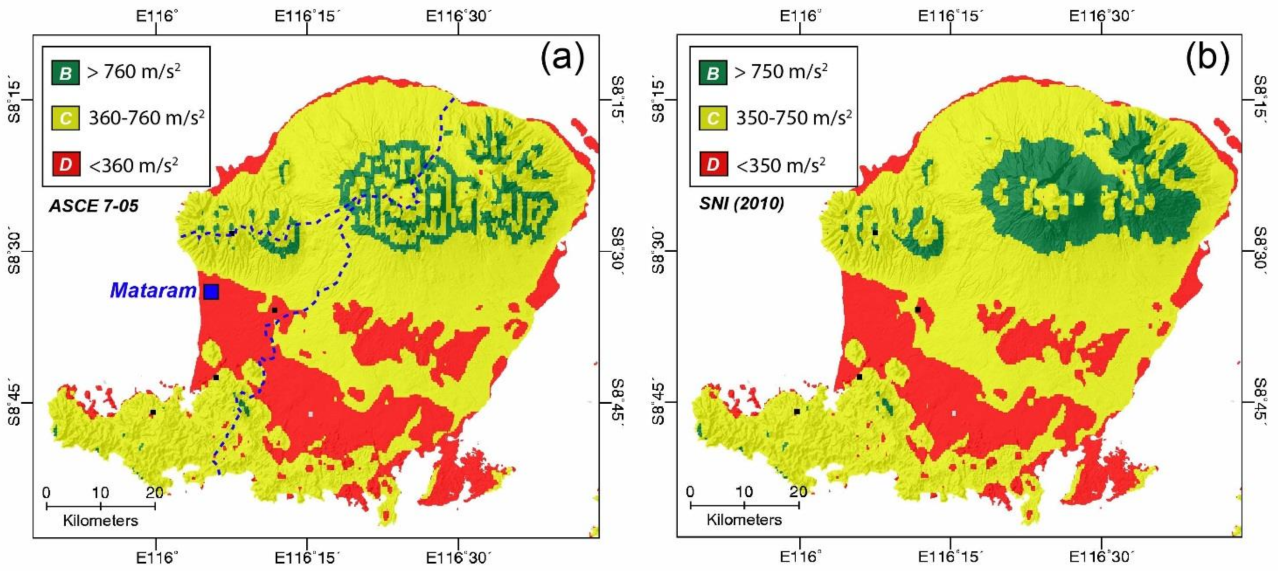


Figure 15 Site classification, according to (a) ASCE 7-05, and (b) 2010 Indonesian Seismic Design Code for Lombok Island.

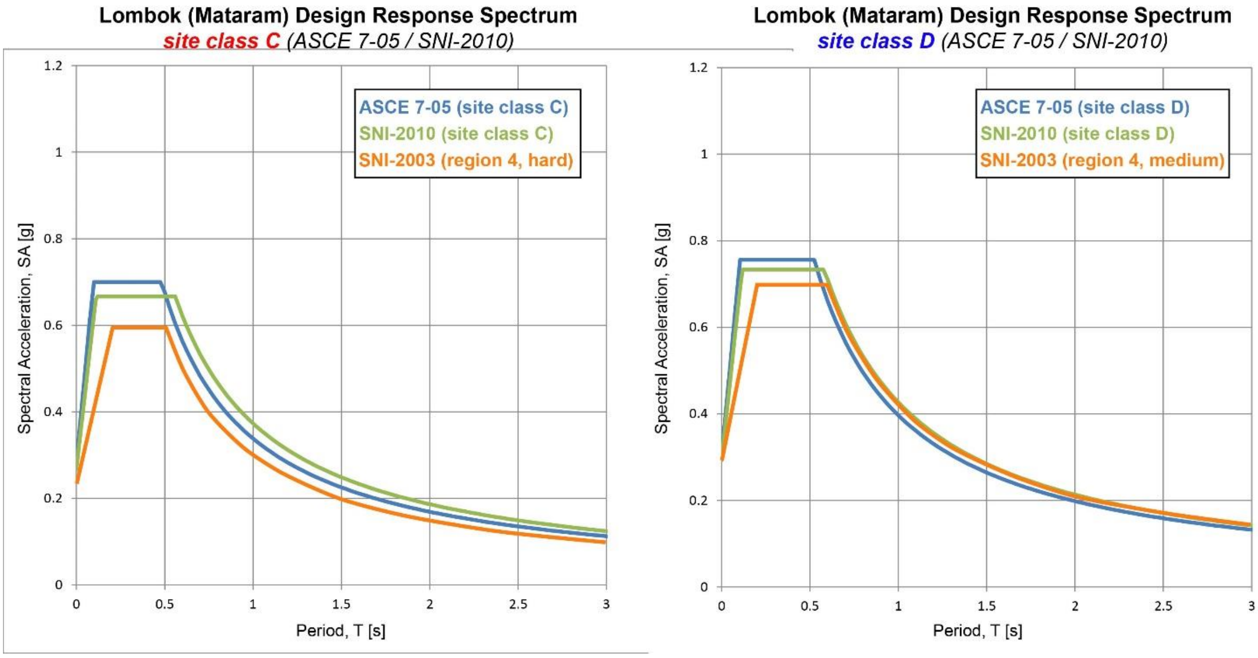


Figure 16 ASCE 7-05 and SNI (2010) design response spectra for site class C and D in North and West Lombok.

5 Key Points and Conclusions

• The latest update to the Indonesia building code (SNI-2010) represents a significant improvement on the earlier 2002 version of the code. The 2010 code was updated following the devastating 2004 earthquake; it is based on the ASCE 7-05 building code, and incorporates more recent estimates of Ss and S1 accelerations across the country.
• The design spectra for Padang, based on SNI-2010, is significantly different from both ASCE 7-05 and SNI-2002, yielding ~20% higher spectral accelerations between T0 and Ts.
• The SNI-2010 design spectra for North and West Lombok are similar to ASCE 7-05, while slightly higher than SNI-2002.
• Geospasial BNPD in Indonesia provides good country-wide hazard and risk maps. Nevertheless, more detailed local-scale maps are needed to better assess the risk and hazard posed to cities and populations throughout the country. BNPD appear to be gradually addressing this issue.
• The decentralised nature of Indonesian governance hinders the transfer of knowledge and experience and responsibility for better understanding geohazards throughout the country.
• Further work is required to better characterise the site conditions throughout Indonesia. The only publicly available data is the USGS VS30 maps, which are known to be imperfect for assessing site conditions. Correct determination of site class is essential for better quantifying the true hazard posed by earthquake ground shaking.
• While the seismic hazard in Padang is relatively well understood, Lombok Island also sits above a seismic gap on the Sunda subduction zone, and therefore is also at significant risk from future earthquakes (and associated secondary hazards). Despite this we noticed much less information is generally available on the active tectonics and earthquake hazard in Lombok compared to Padang. This problem is likely to be true of many other islands throughout the region.
• The SW coastline of Indonesia, facing the Sunda trench, is at risk from future large earthquakes and tsunamis along its entire length. The NE-facing coastal regions of these islands (Sumatra, Java, Bali, etc) are at lower risk from Sunda Megathrust earthquakes, although these lower lying regions experience increased flooding hazard.
• In the scientific literature, relatively little discussion is given to the earthquake hazard posed by the Great Sumatran strike-slip fault, which passes just 15 km east of the city. Relatively little is known about this fault regarding its past history of earthquakes. Such a long and fast-moving fault as this will be capable of producing very large earthquakes in the future. Furthermore, as this is a strike-slip fault, it may also be capable of producing directivity effects, which can significantly enhance ground shaking in the direction of fault rupture.
• Indonesia faces three significant challenges in better characterizing the hazard posed by active faults: 1. The Sunda Megathrust lies offshore, and is therefore challenging to monitor with space-based geodetic methods, such as InSAR and GPS. 2. Much of the country is densely vegetated, which obscures many active structures and hampers fault trenching studies, which can better characterize the earthquake slip histories. Future surveying using airborne LiDAR will allow high resolution digital topographic models of the ground (with and without tree cover) to be produced. 3. Detailed fault studies require highly specialized skills, are time consuming and expensive. Furthermore, much of the global expertise in this area is focused in Europe, N. America and Japan.
• A key factor which controls the magnitude of tsunami waves for an area is the morphology of the shallow coastal region. Shallow coastal bathymetric data is typically the most challenging (and expensive) data to acquire. Credible site-specific tsunami hazard studies will need detailed coastal bathymetric data to reliably assess the true tsunami hazard.

6 References

[1] D. L. Wells and K. J. Coppersmith, "New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement," *Bulletin of the Seismological Society of America,* vol. 84, no. 4, pp. 974-1002, 1992.

[2] Satkorlak, *Recapitulation of West Sumatra EQ Impacts - Friday, October 23,* UN OCHA, Sumatra, 2009.

[3] J. McCloskey, D. Lange, F. Tilmann, S. Nalbant, A. Bell, D. Hilman Natawidjaja and A. Rietbrock, "The September 2009 Padang earthquake," *Nature Geoscience,* vol. 3, pp. 70-71, 2010.

[4] J. Borrero, K. Sieh, M. Chlieh and C. Synolakis, "Tsunami inundation modeling for western Sumatr," in *Proceedings of The National Academy of Sciences,* 2006.

[5] T. Schlurmann, W. Kongko, G. N. D. Natawidjaja and K. Sieh, "Near-field tsunami hazard map Padang, West Sumatra: utilizing high resolution geospatial data and reseasonable source scenarios," in *Coastal Engineering Proceedings,* 2010.

[6] A. Tohari, K. Sugianti and E. Soebowo, "Liquefaction Potential At Padang City: A Comparison of Predicted and Observed Liquefactions During The 2009 Padang Earthquak," *Jurnal Riset Geologi dan Pertambangan,* vol. 21, no. 1, pp. 7-18, 2012.

[7] Ö. Aydan, "A reconnaisance report on the Pariaman-Padang earthquake of September 30, 2009," Japan Society of Civil Engineers, Japan Association for Earthquake Engineering, Engineers Without Borders - Japan, 2009.

[8] G. Deierlein, N. Alexander, V. Cedillos, L. Comfort, T. Hart, E. Hausler, S. Henderson and K. Wood, "The Mw 7.6 Western Sumatra Earthquake of September 30, 2009," EERI Special Earthquake Report, 2009.

[9] F. Lavigne, J. Degeai, J. Komorowski, S. Guillet, V. Robert, P. Lahitte, C. Oppenheimer, M. Stoffel, C. Vidal, Surono, I. Pratomo, P. Wassmer, I. Hajdas, D. Hadmoko and E. de Belizal, "Source of the great A.D. 1257 mystery eruption unveiled, Samalas volcano, Rinjani Volcanic Complex, Indonesia," 2013.

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	James Hollingsworth	Katherine Coates	Ziggy Lubkowski
Signature			

B2 Flood Hazards Affecting Padang

File Note

ARUP

Central Square
Forth Street
Newcastle upon Tyne NE1 3PL
United Kingdom
www.arup.com

t +44 191 261 6080
f +44 191 261 7879

Project title	Indonesia Hazard Study	Job number	238204-01
cc		File reference	
Prepared by		Date	28 November 2014
Subject	Padang Flood Hazard Study		

Contents

File Note

238204-01 28 November 2014

1 Introduction

Flooding has been identified as a potential hazard to schools in Padang. Parts of the city have experienced severe flooding on a number of occasions.

Flood risk in the city is a function of the existing rainfall patterns and topography, with high intensity rainfall and the city being located in a flat coastal location downstream of a hilly region.

This short note is designed to provide a brief understanding of the nature of flood risk in Padang, a concise overview of the key issues that would need to be considered both by those assessing the vulnerability of existing schools to flooding or those planning a programme of new schools, and a rapid assessment checklist that can be used to identify the relative vulnerability of existing schools.

2 Flood risk theory and concepts

Flood risk is generally understood to be a function of probability and consequences, where:

- **Probability** is the measure of the **likelihood** that an identified **hazard** will occur (e.g. a flood depth exceeding 1 m at a given location). It is considered over a specific timeframe (e.g. one tidal cycle, one month, one year, a lifetime). The concept of probability can be extended further to consider the chance of receptors being exposed to flooding and, therefore, of experiencing adverse consequences.
- **Consequences** express the degree of harm suffered by a receptor, or group of receptors, as a result of a given flood event. Consequences can be subdivided into two key components – **exposure** and **vulnerability/degree of resilience.**

It is important to note that flood risk is **not stationary in time**. Climate change, land-use change, the deterioration of flood defence systems, and the degree of exposure and vulnerability of receptors can all influence flood risk over time.

The components of flood risk can be analysed using the source–pathway–receptor model (see Table 1), which has its origins in the analysis of contaminated land, but has been adapted for flood risk management purposes. ‘Sources’ constitute flood hazards (anything with the potential to cause harm through flooding). ‘Pathways’ represent the mechanisms by which the flooding hazard would cause harm. ‘Receptors’ comprise the people, property, infrastructure and ecosystems potentially affected should a flood occur. The consequences of flooding for receptors are highly dependent on their degree of vulnerability. For people, vulnerability can be dependent on where they live, their age, income, education and disability, and on broader social and environmental factors such as level of preparedness and quality of emergency service response.

Table 1: Sources, pathways and receptors

Sources	Pathways	Receptors
Rainfall River flows Artificial drainage systems Extreme sea levels Wind-generated waves Tidal storm surges Tsunamis Lakes/Reservoirs Canals Groundwater	Overtopping or failure of river defences Breaching of natural or man-made coastal defences Failure of flood defence components such as barriers and gates Reservoir failure Inundation of floodplains Overland flow Inadequate drainage	People Domestic and commercial property Emergency services installations Infrastructure Agriculture Ecosystems

3 General information

3.1 Climate

Padang has a typical tropical rainforest climate, and has one of the highest rainfall rates in Indonesia, with frequent rainfall throughout the course of the year and at least 10 day of rain on average each month. The wettest months are September to January, although over 100mm are recorded for the other months.

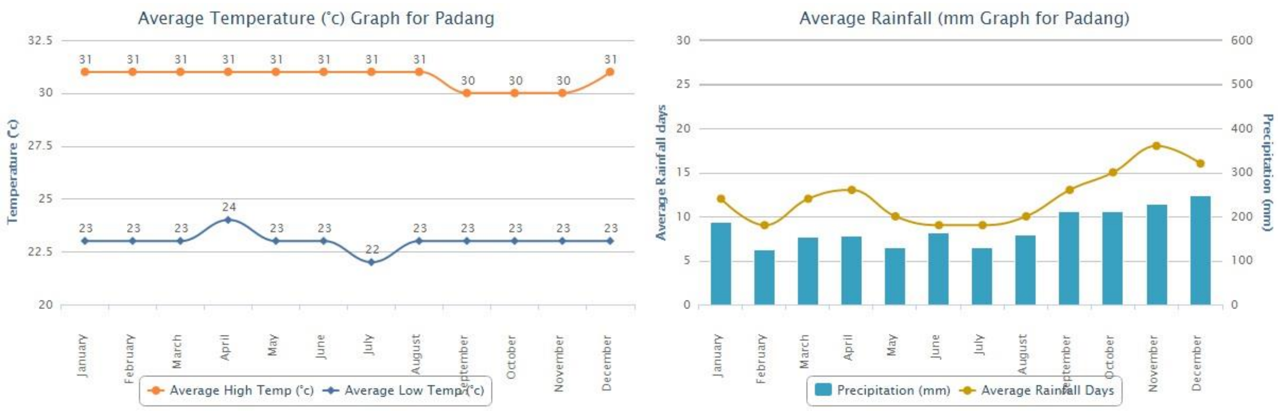


Figure 1: Padang Climate (World Weather Online, 2014)

The intensity of the rainfall events is a key characteristic of the rainfall patterns in this area, with significant depths of precipitation occurring in very short times. IDF curves from Indonesian weather stations show that, in 1 in 2 year return period storms, intensities of 150 mm/h can be recorded over 10 minute periods and intensities can exceed 250 mm/h in 1 in 25 year events (IHP, 2008). This intensity of rainfall means that there are short periods of time when the capacities of natural and artificial drainage systems are exceeded.

3.2 Geography

3.2.1 Location

Padang is the capital of the West Sumatra province and the largest city on the western coast of the island of Sumatra. It is surrounded by a hilly area to the east and south and lies in a flat area by the Indian Ocean, with the island of Pulau Siberut to the west.

Figure 2: Location plan of Padang within Indonesia

3.2.2 Topography

Padang city is located on the coast on what appears to be flat and low lying ground. To the east and south, the urban area is surrounded by a steep hilly region (see Figure 3), rising at its highest points above an altitude of 1,800m. This hilly area is densely forested, and a series of rivers flow in a generally east-west direction via incised valleys from the steep hills towards the coast. Through the urban areas, these are generally heavily channelized, with weirs and other control structures apparent. In the less urban areas, the rivers appear more natural, with large cobbles and boulders within the channel bed.

Figure 3: Padang topography

The geology of the city is mainly composed of recent volcanic rocks and drift sediment in a very active tectonic setting, with soils dominated by lowland podzols. The upper layers of these soils can have a low permeability related to their high organic matter content.

3.3 Economy

Padang is the capital of the West Sumatra province in Indonesia. It has a population over 1.02million, 900,000 of which live in the urban areas and the remaining in the more rural areas in the outskirts and hills.

A significant part of Padang's revenues come from tourism. The service sector is also important and Padang is an important port for trade. It has also some agricultural production, although this has been reduced with increased development in the city.

Although part of the mountainous area to the east and south of Padang is part of National Park, serious illegal logging occurrences taken place in the Padang area, with up to 20 percent of the 12,000 hectares of protected forest within city limits being reported felled by illegal loggers by 2012 (Jakarta Globe, 2012).

3.4 School locations

As would be expected, the distribution of schools on the island mirrors the areas of highest population, with the more sparsely populated areas to the north and near the hilly areas having fewer schools (Figure 4).

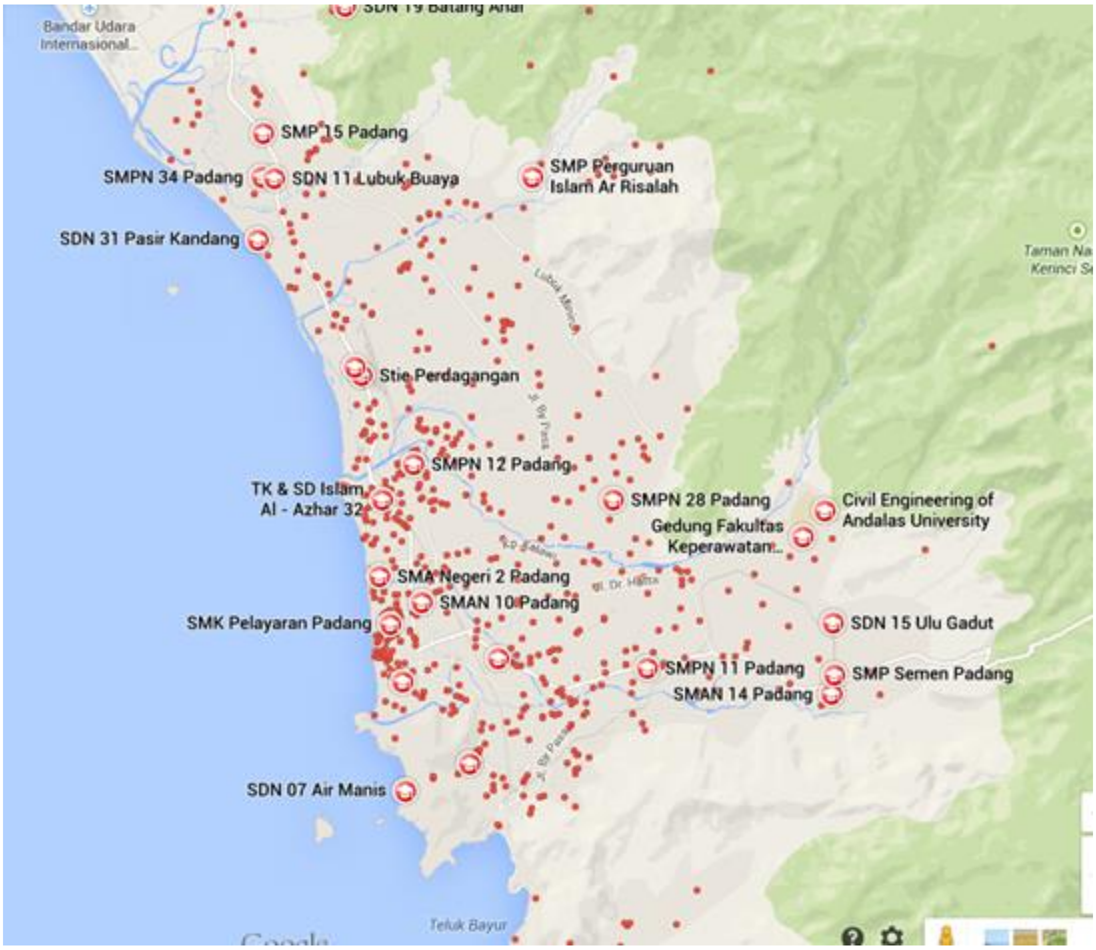


Figure 4: Location of schools

A large concentration of these schools are located in the floodplains of the main rivers flowing from the steep hills in the east onto the coastal plain, which can be seen in Figure 5.

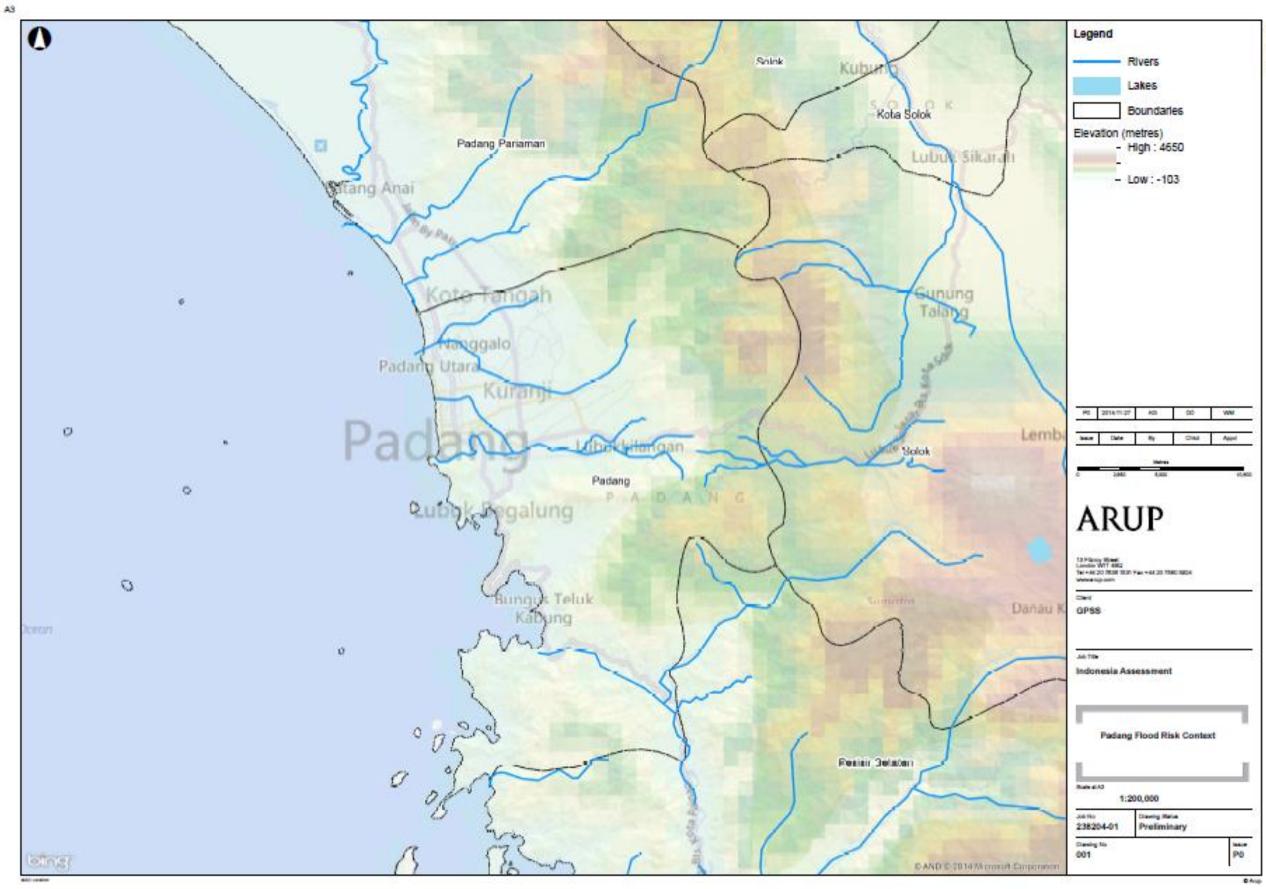


Figure 5: Main rivers flowing from the hills to the coastal plain in Padang

4 Flood risk Legislation

According to the Directorate of Water Resources and Irrigation, there is no specific legislation governing flood prevention, although policy recommendations have been made in a document on Flood Mitigation Policies in Indonesia. The document highlights that flood risk has been increasing in Lombok and other areas in Indonesia due to changes in land use and environmental function. This has been exacerbated by poor drainage systems that have a direct impact on surface runoff.

In 2001, a project financed by the Japan International Cooperation Agency was completed '*to alleviate flood damage in municipal areas of Padang City in Sumatra by implementing river improvements and developing drainage channels, and thereby contribute to social development and economic growth in the region.'* (JICA, 2003). The project developed improvement to allow the rivers acted upon to handle flows up to 1 in 25 year return periods and the drainage network to be able to deal with 1 in 5 year flows. The project was evaluated as being successful and reducing flood damage in subsequent years. The exact extent of the project is unknown, however, and existing pressures from illegal logging may have altered conditions.

5 Flood Hazard Characteristics

5.1 General

The topography and nature of the city influences the existing flood risk pattern, with a low lying flat area located at the base of steep hills. The highest flood risk, based on the country level flood risk assessment, is identified as average in areas east and north of the airport (Figure 6). The national scale data, however, does not capture local details, and does not follow the existing catchment areas showing the contributing areas in the east with susceptible land in the west downstream, as shown by Figure 7. The national scale data (Figure 6) in this location, therefore, does not give an accurate picture of flood hazard.

Rural drainage and urban stormwater systems are also likely to temporarily overwhelmed by extreme rainfall resulting in a flood hazard on low-lying land adjacent to these systems. Illegal logging, widespread in the hills upstream, appears to exacerbate flooding, with increased runoff due to a reduction of the land cover in steep hillsides, increased soil erosion and logs and debris being carried by increased flows and blocking bridges and culverts downstream.

Residential and industrial buildings, major transport infrastructure and agricultural land are all found within the floodplains. Most houses in the residential areas are 1 or 2 storey buildings, with higher modern buildings in the commercial areas and the city centre.

The Climate Change Vulnerability Mapping for Southeast Asia report (Anshory Yusuf and Francisco, 2009) suggest that Padang would be ‘mildly vulnerable’ to the impacts of climate change.

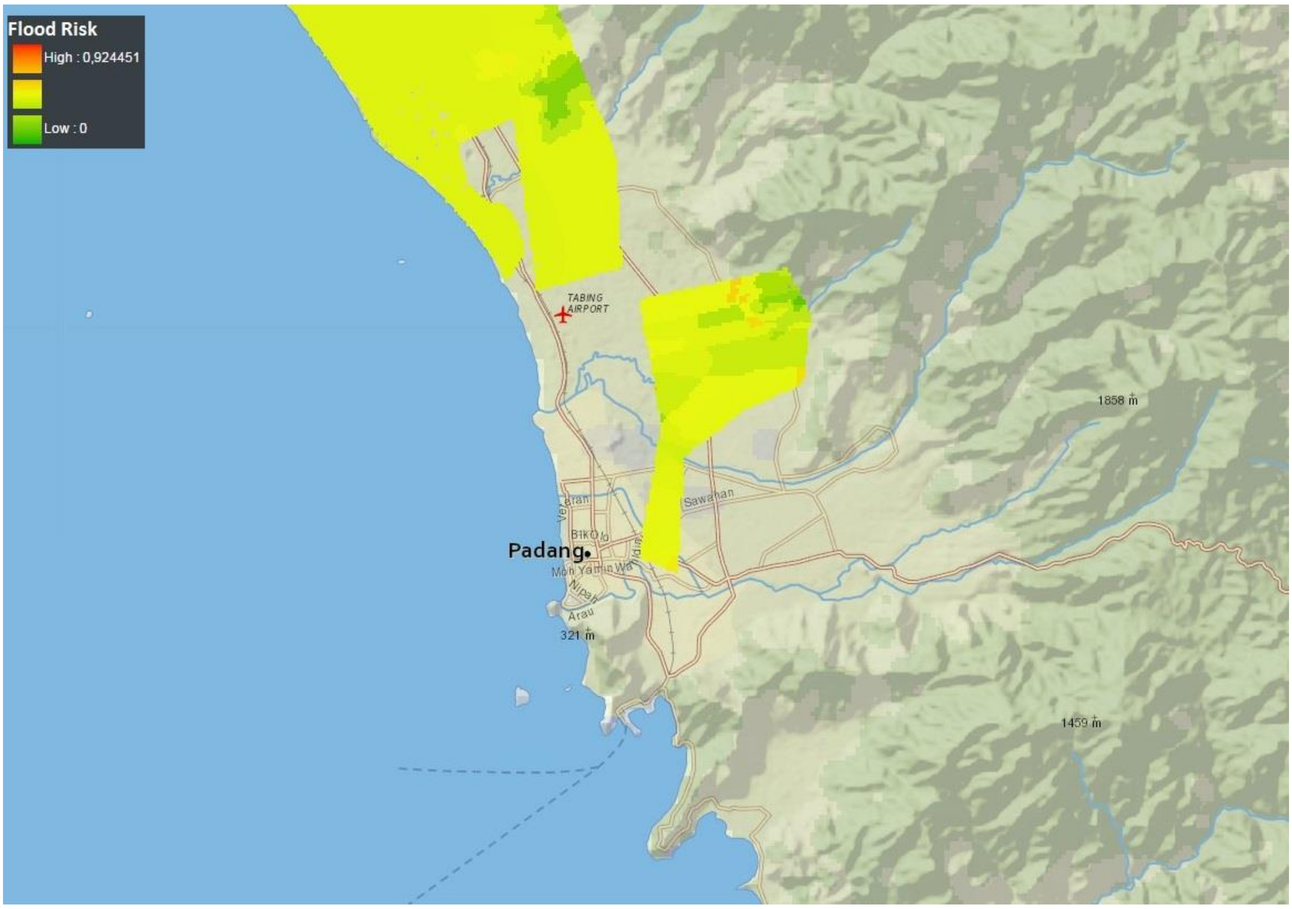


Figure 6: Padang Flood Risk (source: Risk Assessment, Flood Hazard Map Indonesia 2011, from national level data)

File Note

238204-01 28 November 2014

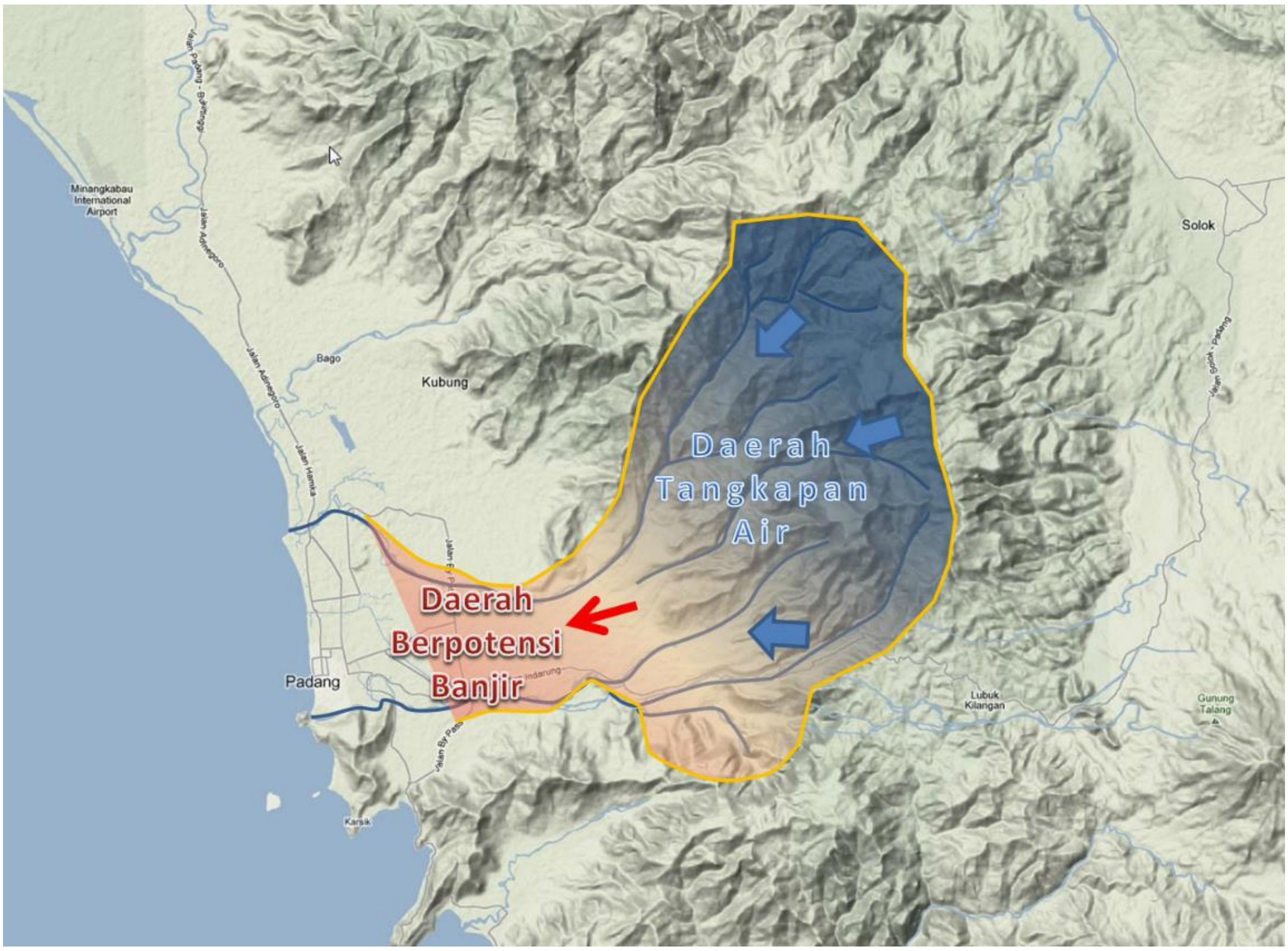


Figure 7: Catchment area (blue) and corresponding potential flood area (red)

5.2 Historic Flooding

Anecdotal evidence of relatively frequent flooding in the island can be found in local press; some examples are included below.

5.2.1 November 2014

Antara News, 2014 - *A flash flood triggered by incessant rain struck Koto Kaciak Village in Pasaman District, West Sumatera Province, Thursday killing a local resident, a National Disaster Mitigation Agency (BNPB) official said.*

5.2.2 July 2012

WHO, 2012 - *On Tuesday, 24 July 2012, a flood was inundated 9 villages in 4 Sub-districts in Padang City, include: Nanggola Sub-district (4 Villages-Tabing Banda, Gurun Laweh, Surau Gadang and Kurao Pagang), Kuranji Sub-district (1 Village-Kalumbuk), Pauh Sub-district (2 Villages-Batu Busuk and Limau Manis), and Lubuk Begalung Sub-district (2 Villages-Baringin and Banuaran). These areas were heavily affected.*

Besides killing Nurbaiti (53), the flood, which hit the village at 05.30 p.m. local time, also forced 70 families to take refuge in a mosque, BNPB spokesman Sutopo Purwo Nugroho stated here Friday.

The flash flood also damaged 30 houses, a mosque, a 12-meter-long road as well as a car and a rice mill machine, he added. Meanwhile, a total of 216 people from 41 families were evacuated due to flash floods at Tabiang Banda Gadang in Nanngalo Sub-District, Padang city, about three hours from Pasaman.

The floodwaters inundating the area reached up to two meters high. The BPBD has erected emergency tents and distributed ready-to-eat meals to flood-affected people.

5.2.3 July 2012

Jakarta Globe, 2012 - *Heavy rains caused the Lubuk Linggau and Batang Kuranji rivers to overflow, forcing hundreds of families to flee their homes for safety and causing 8 fatalities. The city major named illegal logging as a major cause for the grave impacts of the flooding.*

5.3 Flood hazard conclusions

Little data is readily available on the detailed nature of the flood hazard. The geography and topography indicates that the key mechanism is likely to be river flooding. The rivers are relatively small and steep over their upper reaches in particular. They are likely to respond rapidly to rainfall, giving little time for provision of flood warnings, unless these were based on weather radar. The likelihood of fast-flowing and destructive floods occurring is relatively high. As these river flowing from the high mountains meet the coastal plain to the west, they are likely to be associated with floodplain areas, where floodwater may be less fast flowing, but distributed over a wider area.

Rural drainage and urban stormwater systems are also likely to temporarily overwhelmed by extreme rainfall resulting in a flood hazard on low-lying land adjacent to these systems. This risk is likely to be further exacerbated by illegal logging in the steep hillsides.

Assessing the likelihood of schools being exposed to the flood hazard will therefore require careful consideration of the local topography and drainage pathways. Low-lying land next to rivers will clearly be at risk, but assessors should look out for the more subtle routes that might be taken by floodwater if the schools lie downslope from rivers, watercourses of artificial drainage systems. Local people will be the best source of data on historic flooding. However, just because a site has not flooded in the past, it does not mean that there is no risk. Ultimately, expert advice will be required.

6 School Building exposure and vulnerability

The Indonesian Ministry of Education and Culture (Kementerian Pendidikan dan Kebudayaan) has proposed a methodology to assess the condition of school buildings, estimating of 22.5% of school building in the country show very poor condition (heavy damage), while a further 35% show poor condition (lower level of damage). In the West Sumatra province, the percentage of very poor condition (heavy damage) schools is 15.01%. The Ministry of Education proposed in 2010 a programme for the Rehabilitation of Primary Schools and Junior High Schools.

In Padang, newer school buildings appear to be made of concrete and look well built, with 1 to 3 stories. Older schools seem to be mixed, some concrete, and other with a variety of materials, some of which may be more susceptible to damage by flooding. Some of these older building appear to be in very poor conditions, as highlighted by the assessment of the Ministry of Education.

There are no specific building codes relating to flood design / resilience, although aspects of flood resilience may be included in other building codes.

It is therefore likely that schools will not be specifically constructed with flood resilience in mind, unless measures have been retrofitted as a response to historic flooding.

It is reported that there has been a lack of strategic city planning regarding drainage, with difficulties in agreeing a revised plan to deal with new development. This is exacerbating flood risk in the established parts of the city. It has also been reported that frequent flooding occurs as a result of blocked drains and sewers as these are not regularly cleared and cleaned. It is further reported that the Office of Administration Building spatial planning (TRTB) in Padang, as the competent authority, is not ensuring proper drainage is constructed when granting new building permits. *(http://www.antarasumbar.com/eng/news/padang/d/2/10251/80-percent-of-districts--cities-have-not-masterplan-drainage.html)*

7 Conclusions

A high level assessment based on the limited available data suggests that there is potential flood risk from fluvial and surface runoff flooding to a proportion of the areas where most schools in Padang are located. The main conclusions are listed below.

- There is limited information on flood risk at specific sites – more data may be available, and understanding this will be very helpful when considering specific sites.
- A flood alleviation scheme was completed in 2001, reducing risk (reportedly) to 1:25 each year from river and 1:5 from drainage system.
- Reported problems with the drainage system and pressures of development are likely to lead to increasing flood risk. Illegal logging is also reported to be exacerbating flooding issues.
- Flooding is likely to occur as a result of high intensity rainfall causing rivers to overtop their banks. Such rainfall is also likely to overwhelm local drainage systems. Low-lying land next to rivers will clearly be at risk, but assessors should look out for the more subtle routes that might be taken by floodwater if the schools lie downslope from rivers, watercourses of artificial drainage systems.
- The flood resilience of existing buildings is difficult to determine, however the lack of formal building codes is likely to mean that schools will not be specifically constructed with flood resilience in mind.

8 References

Antara News. (2013, 12 5). *Hundreds of houses flooded in Lombok after heavy rain*. Retrieved from Antara News: http://www.antaranews.com/en/news/91717/hundreds-of-houses-flooded-in-lombok-after-heavy-rain

Lombok Network. (2006, 11 24). *Flash Flood Hit Four Villages in East Lombok*. Retrieved from Lombok Network: http://www.lombok-network.com/lombok_news/flash_flood_east_lombok.htm

The Jakarta Post. (2012, 03 14). *Flash flood hits East Lombok*. Retrieved from The Jakarta Post: http://www.thejakartapost.com/news/2012/03/14/flash-flood-hits-east-lombok.html

Waspada Online. (2010, 09 27). *Flood inundates houses in West Lombok*. Retrieved from Waspada Online: http://waspada.co.id/index.php?option=com_content&view=article&id=145675:flood-inundates-houses-in-west-lombok&catid=30:english-news&Itemid=101

World Weather Online. (2014, 11 21). *Lombok Monthly Climate Average, Indonesia*. Retrieved from World Weather Online: http://www.worldweatheronline.com/Lombok-weather-averages/Nusa-Tenggara-Barat/ID.aspx

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name			
Signature			

B3 Flood Hazards Affecting Lombok

File Note

ARUP

Central Square
Forth Street
Newcastle upon Tyne NE1 3PL
United Kingdom
www.arup.com

t +44 191 261 6080
f +44 191 261 7879

Project title	Indonesia Hazard Study	Job number	238204-01
cc		File reference	
Prepared by		Date	28 November 2014
Subject	Lombok Flood Risk Hazard Study		

Contents

File Note

238204-01 28 November 2014

1 Introduction

Flooding has been identified as a potential hazard to schools on Lombok Island. Parts of the island have experienced severe flooding on a number of occasions.

Flood risk on the island is a function of the existing rainfall patterns and topography, with high intensity, short duration rainfall following dry periods, and a low flat area running through the centre of the island which receives floodwater runoff from steep hilly areas in the north and south.

This short note is designed to provide a brief understanding of the nature of flood risk on Lombok Island, a concise overview of the key issues that would need to be considered both by those assessing the vulnerability of existing schools to flooding or those planning a programme of new schools, and a rapid assessment checklist that can be used to identify the relative vulnerability of existing schools.

2 Flood risk theory and concepts

Flood risk is generally understood to be a function of probability and consequences, where:

- **Probability** is the measure of the **likelihood** that an identified **hazard** will occur (e.g. a flood depth exceeding 1 m at a given location). It is considered over a specific timeframe (e.g. one tidal cycle, one month, one year, a lifetime). The concept of probability can be extended further to consider the chance of receptors being exposed to flooding and, therefore, of experiencing adverse consequences.
- **Consequences** express the degree of harm suffered by a receptor, or group of receptors, as a result of a given flood event. Consequences can be subdivided into two key components – **exposure** and **vulnerability/degree of resilience.**

It is important to note that flood risk is **not stationary in time**. Climate change, land-use change, the deterioration of flood defence systems, and the degree of exposure and vulnerability of receptors can all influence flood risk over time.

The components of flood risk can be analysed using the source–pathway–receptor model (see Table 1), which has its origins in the analysis of contaminated land, but has been adapted for flood risk management purposes. '**Sources**' constitute flood hazards (anything with the potential to cause harm through flooding). '**Pathways**' represent the mechanisms by which the flooding hazard would cause harm. **'Receptors'** comprise the people, property, infrastructure and ecosystems potentially affected should a flood occur. The consequences of flooding for receptors are highly dependent on their degree of vulnerability. For people, vulnerability can be dependent on where they live, their age, income, education and disability, and on broader social and environmental factors such as level of preparedness and quality of emergency service response.

Table 1: Sources, pathways and receptors

Sources	Pathways	Receptors
Rainfall River flows Artificial drainage systems Extreme sea levels Wind-generated waves Tidal storm surges Tsunamis Lakes/Reservoirs Canals Groundwater	Overtopping or failure of river defences Breaching of natural or man-made coastal defences Failure of flood defence components such as barriers and gates Reservoir failure Inundation of floodplains Overland flow Inadequate drainage	People Domestic and commercial property Emergency services installations Infrastructure Agriculture Ecosystems

3 Relevant background information

3.1 Climate

Rainfall patterns in Lombok show a clear bi-seasonal distribution typical of tropical climates with very low precipitation between May and September, and increase precipitation from October to April (Figure). This pattern leads to heavy rainfall events in the wet season that can cause flooding, but also to periods of drought in the dry season, which can have an impact on ground conditions and further exacerbate the impacts of heavy precipitation in the following wet season.

Figure 1: Climate data for Lombok (World Weather Online, 2014)

The intensity of the rainfall events is a key characteristic of the rainfall patterns in this area, with significant depths of precipitation occurring in very short times. IDF curves from Indonesian weather stations show that, in 1 in 2 year return period storms, intensities of 150 mm/h can be recorded over 10 minute periods and intensities can exceed 250 mm/h in 1 in 25 year events (IHP, 2008). This intensity of rainfall means that there are short periods of time when the capacities of natural and artificial drainage systems are exceeded.

3.2 Geography

3.2.1 Location

Lombok is a volcanic island in Indonesia, within the Nusa Tenggara Barat province. It is located between the islands of Bali and Sumbawa (see Figure 1). It's defined by high land in the north and south, and lowlands in the central part of the islands. Its provincial capital, and highest population concentration is Mataram, is located in the western coast of the lowlands.

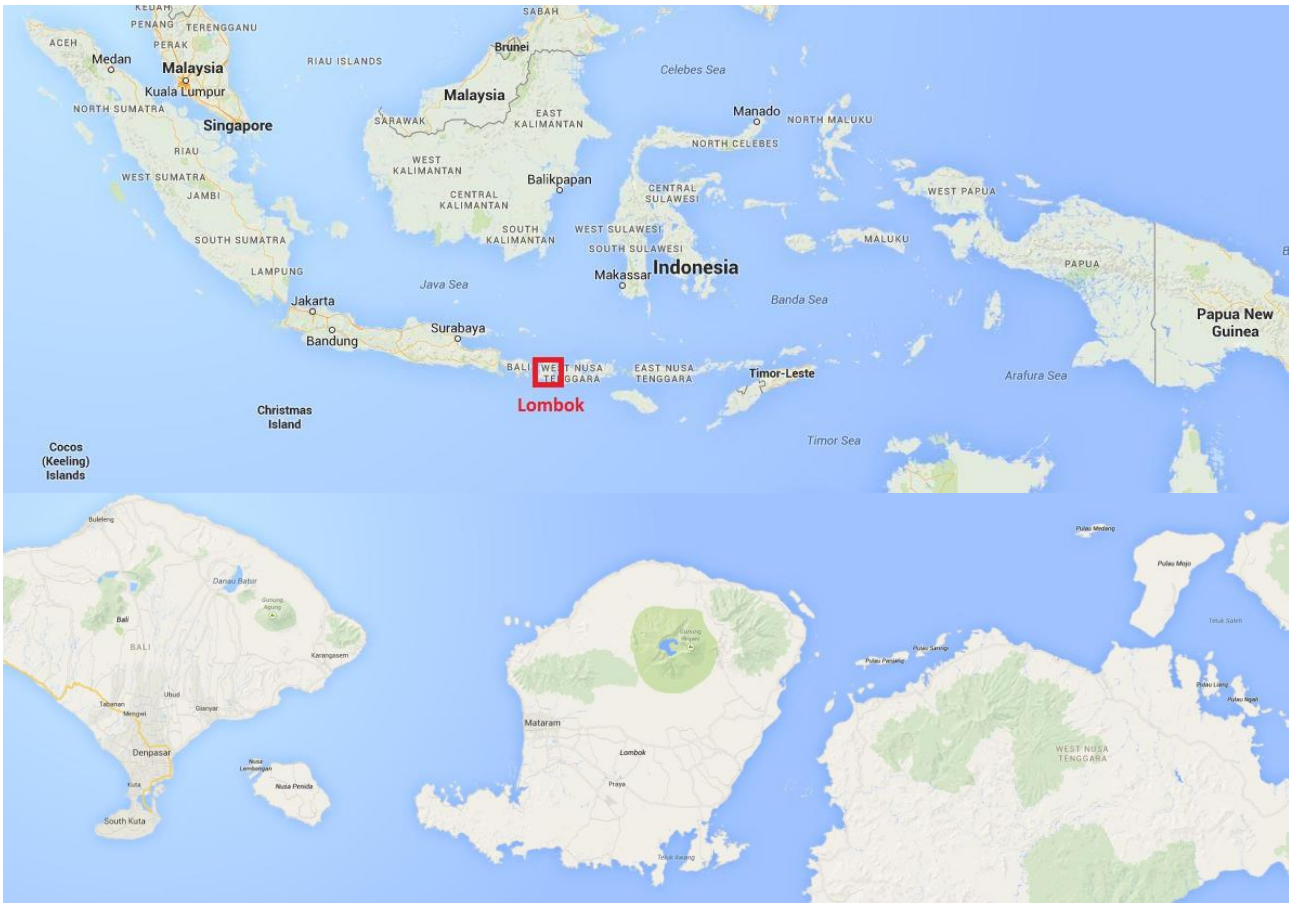


Figure 1: Location of Lombok within Indonesia

3.2.2 Topography

The northern part of the island is volcanic and has Mount Rinjani in the centre, which is the second highest volcano in Indonesia with a peak of 3,726m. The central section is low lying and flat, with a hilly region in the southwest (see Figure 2). This topography creates a dense network of rivers flowing from the high areas onto the central flat areas and the coast.

Figure 2: Lombok Topography

The geology of the island is mainly composed of recent volcanic rocks, with soils in the lowlands dominated by gromusols and chocolate soils, with low permeability due to a high clay content, and regosols, which are more permeable.

3.3 Economy

Lombok has a population of 3.3 million and a population density of 733/km^2. Approximately 12% live in Mataram, which is the largest city on the island and the capital of the West Nusa Tenggara province. The island is split into 5 regions: North Lombok Regency (Lombok Utara); West Lombok Regency (Lombok Barat); Central Lombok Regency (Lombok Tengah); East Lombok Regency (Lombok Timur) and Mataram City. The north regency is the most sparsely populated at 269/km^2 and the other three rural regions are similar from 720-744/km^2.

Most of the highland areas in the north and south are relatively undeveloped and covered in tropical forest, although illegal logging occurrences have been reported (WWF, 2009), whilst the lowlands, with fertile soils, are highly cultivated, with crops such as rice, tobacco, cotton, and coffee. Tourism is a growing economic activity in the island.

The increase of water intensive cultivation tourism and population has put pressure on water resources, especially in the dry seasons, causing water scarcity and droughts (Jakarta Post, 2014, WWF, 2009).

3.4 School locations

As would be expected, the distribution of schools on the island mirrors the areas of highest population, with the more sparsely populated areas having fewer schools, and the highest density of schools found around Mataram and the towns in near the eastern coast of the central area, such as Selong and Masgabik.

Figure 3).

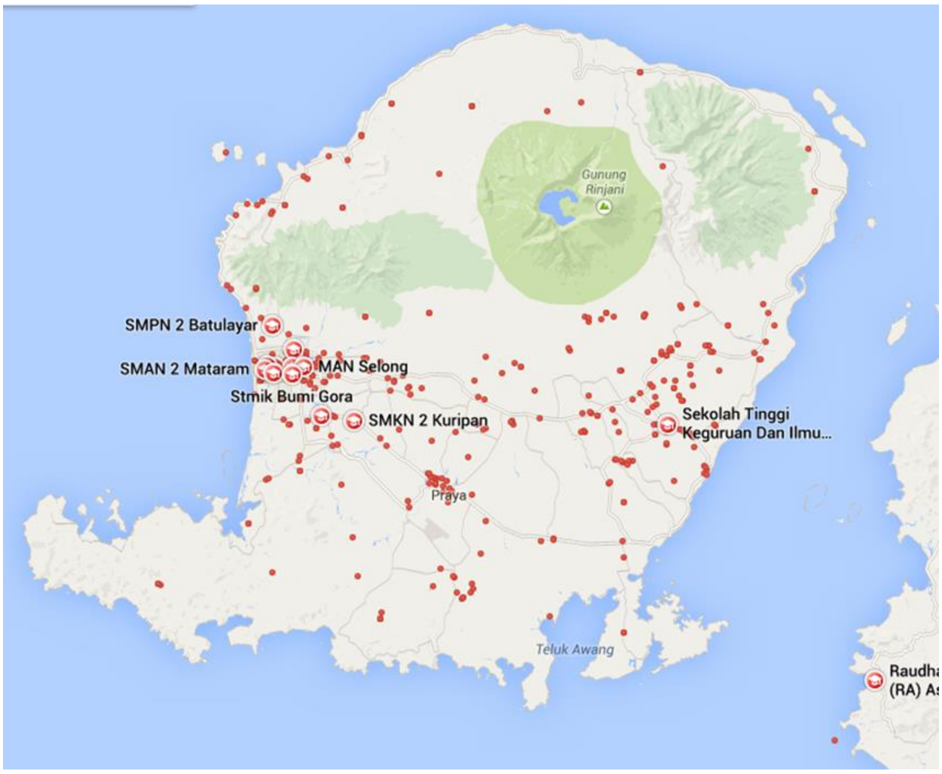


Figure 3: Location of schools in the island of Lombok (source: Google Maps)

The schools identified in the Schools spreadsheet for the project are located in the West and south-western parts of the island (Figure 4).

File Note

238204-01 28 November 2014

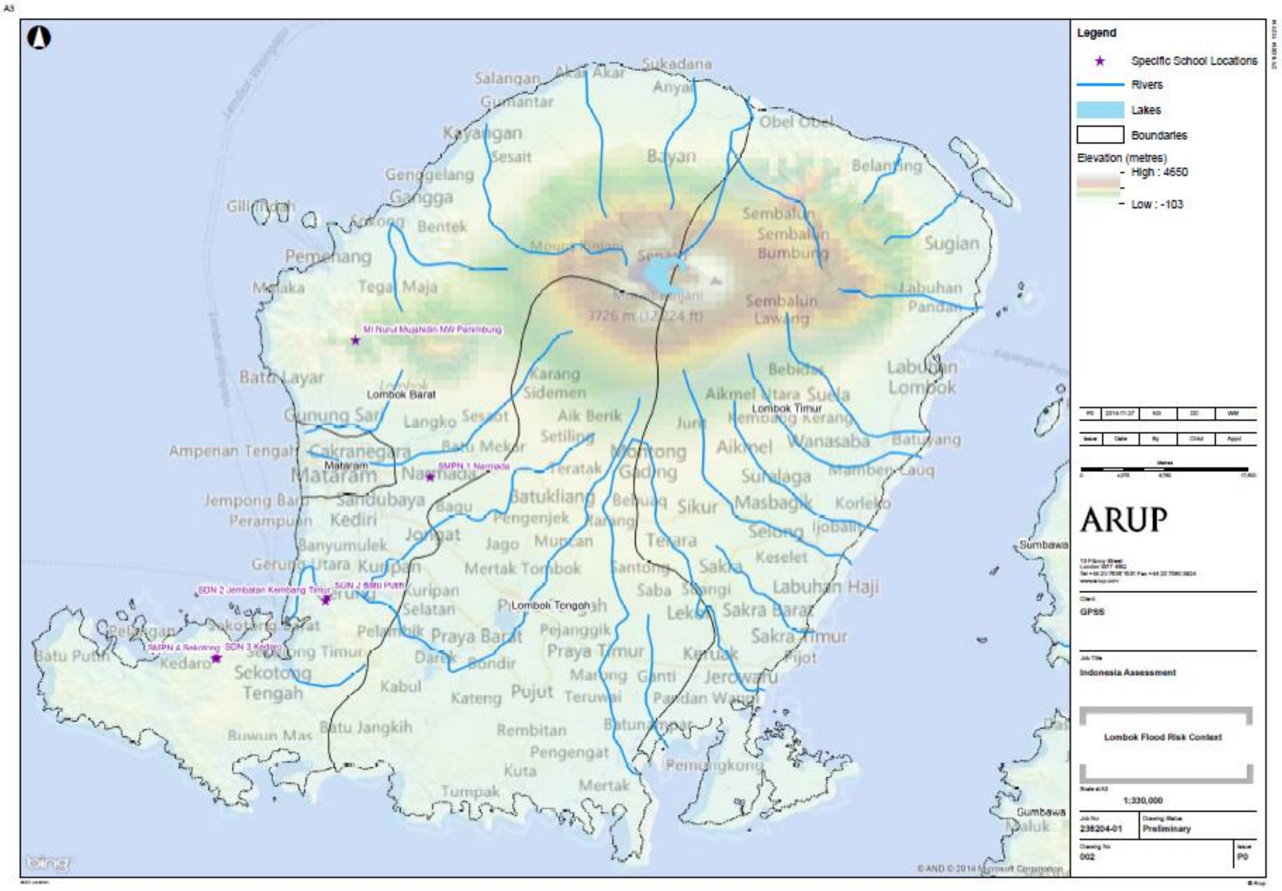


Figure 4 Location of Schools from the schools spreadsheet and main fluvial flow paths

4 Flood Risk Legislation

According to the Directorate of Water Resources and Irrigation, there is no specific legislation governing flood prevention, although policy recommendations have been made in a document on Flood Mitigation Policies in Indonesia. The document highlights that flood risk has been increasing in Lombok and other areas in Indonesia due to changes in land use and environmental function. This has been exacerbated by poor drainage systems that have a direct impact on surface runoff.

5 Flood Hazard Characteristics

5.1 General

The topography of the island and the susceptibility of the area to high intensity rainfall are the principal influences on the existing pattern of flood risk. The highest flood risk area, based on the country level flood risk assessment, is identified around the capital Mataram (Figure 5), thus putting pressure on the highest concentration of residential properties, services and population. The national scale data, however, will not capture local details, and it is likely that other areas of river side and low-lying land through the central area will also be at risk, as shown by some of the examples in Section 3.2.

Rural drainage and urban stormwater systems are also likely to temporarily overwhelmed by extreme rainfall resulting in a flood hazard on low-lying land adjacent to these systems.

Residential and industrial buildings, major transport infrastructure and agricultural land are all found within the floodplains, which are extensive in the central area given the dense river network, and are therefore susceptible to flooding. Most houses in the developed areas are 1 or 2 story buildings. Traditional wooden and grass housing, although limited, is still found in the rural areas of the eastern part of the island.

5.2 Historic flooding

Anecdotal evidence of relatively frequent flooding in the island can be found in local press; some examples are included below.

5.2.1 December 2013

West Lombok, West Nusa Tenggara (ANTARA News, 2013) - *Floods inundated hundreds of houses and an elementary school building in the Suka Makmur Gerung Village in the West Lombok District of the West Nusa Tenggara Province, after the Babak River started overflowing on Thursday.*

The flood waters height reached 100 centimetres and it also washed away two residences belonging to Amaq Junaedi and Mashul. The flood water also washed away some semi-permanent houses and swept garbage, as well as tree branches.

5.2.2 March 2012

Sambelia and Sembalum (The Jakarta Post, 2012) - *Early information from local district officials saying that the flood had swept away a bridge connecting Sambelia and Sembalun districts, and the resident had to be evacuated to higher ground.*

5.2.3 September 2010

WEST LOMBOK, W NUSA TENGGARA (Waspada Online, 2010) - *Incessant heavy rains caused flood in Gelangsar village, Gunung Sari sub district, West Lombok District, NTB Province, Saturday evening (Sep.25). The flood reached a height of up to over one meter, submerged and damaged at least five houses in the village.*

5.2.4 November 2006

East Lombok (Lombok Network, 2006) - *Seasonal downpours triggered floods in most areas in eastern part of Indonesia including some part of east Lombok.*

5.2.5 2006

Sambelia, (The Jakarta Post, 2012) – *Sambelia, located about 130 kilometers from the province's capital Mataram, was struck by a flash flood in 2006. The flood claimed two lives and destroyed hundreds of houses and left more than 2,000 people homeless*

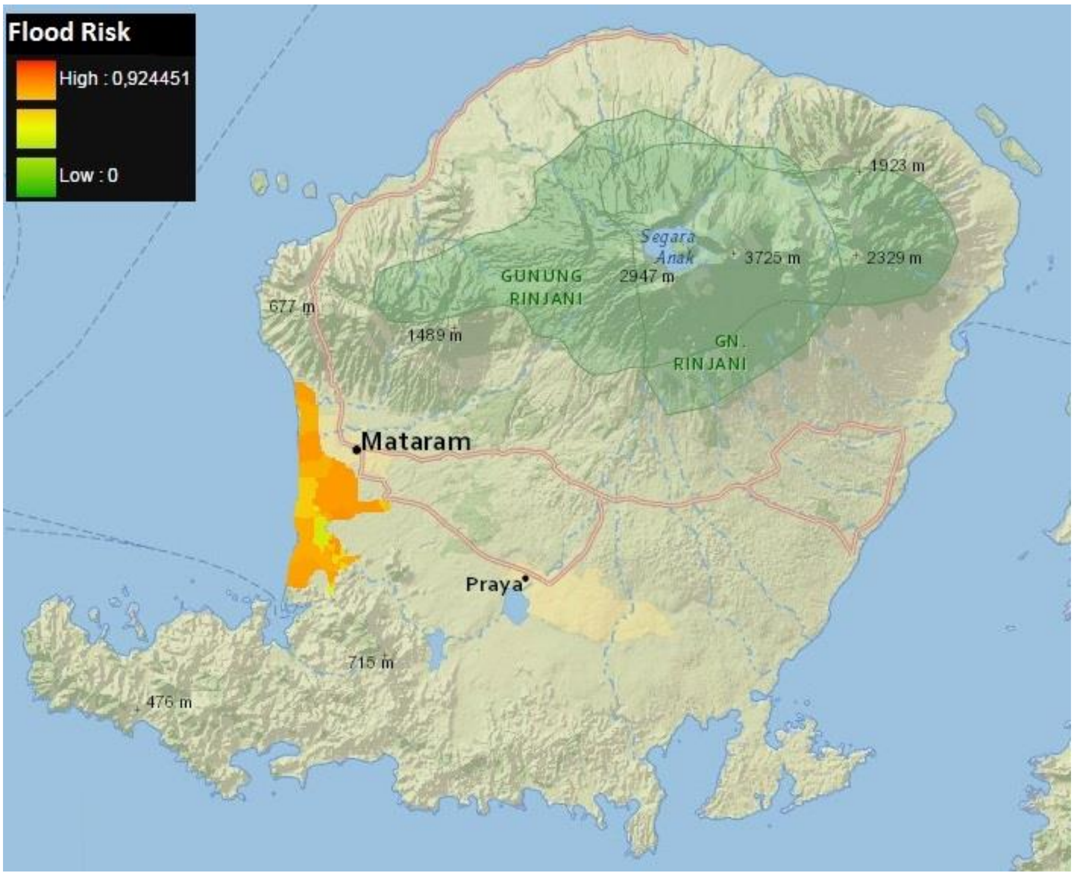


Figure 5: Flood Risk for Lombok (source: Risk Assessment, Flood Hazard Map Indonesia 2011, from national level data)

The Climate Change Vulnerability Mapping for Southeast Asia report (Anshory Yusuf and Francisco, 2009), suggest that only the northeastern part of Lombok would be vulnerable, and even in that case that area is classified as ‘mildly vulnerable’.

5.3 Flood hazard conclusions

Little date is readily available on the detailed nature of the flood hazard in Lombok. The geography and topography indicate that the key mechanism is likely to be river flooding. The rivers are relatively small and steep over their upper reaches in particular. They are likely to respond rapidly to rainfall, giving little time for provision of flood warnings, unless these were based on weather radar. The likelihood of fast-flowing and destructive floods occurring is relatively high. As these steep southern flowing rivers meet the central plain, they are likely to be associated with floodplain areas, where floodwater may be less fast flowing, but distributed over a wider area.

Rural drainage and urban stormwater systems are also likely to temporarily overwhelmed by extreme rainfall resulting in a flood hazard on low-lying land adjacent to these systems.

Assessing the likelihood of schools being exposed to the flood hazard will therefore require careful consideration of the local topography and drainage pathways. Low-lying land next to rivers will clearly be at risk, but assessors should look out for the more subtle routes that might be taken by floodwater if the schools lie downslope from rivers, watercourses of artificial drainage systems. Local people will be the best source of data on historic flooding. However, just because a site has not flooded in the past, it does not mean that there is no risk. Ultimately, expert advice will be required.

6 School building exposure and vulnerability

The Indonesian Ministry of Education and Culture (Kementerian Pendidikan dan Kebudayaan) has proposed a methodology to assess the condition of school buildings, estimating of 22.5% of school building in the country show very poor condition (heavy damage), while a further 35% show poor condition (lower level of damage). In the Nusa Tenggara Barat province, the percentage of very poor condition (heavy damage) schools is 12.9%. The Ministry of Education proposed a programme for the Rehabilitation of Primary Schools and Junior High Schools in 2010.

Newer school buildings seem to be made of concrete and look well built. Older schools seem to be mixed, with some concrete ones and other made with a variety of materials, some of which may be more susceptible to damage by flooding. Some of these older building appear to be in very poor conditions, as highlighted by the assessment of the Ministry of Education.

The northernmost and southernmost schools in the schools spreadsheet appear to be located away from the main rivers in the island, and in one case, on higher ground. They are, however, near some of the smaller streams that make up the very dense watercourse network in the island. The remaining schools are located either by the banks or in the floodplain of the main rivers in the western part of the central plain.

There are no specific building codes relating to flood design / resilience, although aspects of flood resilience may be included in other building codes.

It is therefore likely that schools will not be specifically constructed with flood resilience in mind, unless measures have been retrofitted as a response to historic flooding.

7 Conclusions

A high level assessment based on the limited available data suggests that there is potential flood risk from fluvial and surface runoff flooding to a proportion of the areas where most schools in Lombok are located. The main conclusions are listed below.

- There is limited information on flood risk at specific sites – more data may be available, and understanding this will be very helpful when considering specific areas.
- Flooding is likely to occur as a result of high intensity rainfall causing rivers to overtop their banks. Such rainfall is also likely to overwhelm local drainage systems. Low-lying land next to rivers will clearly be at risk, but assessors should look out for the more subtle routes that might be taken by floodwater if the schools lie downslope from rivers, watercourses of artificial drainage systems.
- Flood resilience of existing buildings is difficult to determine, however the lack of formal building codes is likely to mean that schools will not be specifically constructed with flood resilience in mind.

8 References

Antara News. (2013, 12 5). *Hundreds of houses flooded in Lombok after heavy rain*. Retrieved from Antara News: http://www.antaranews.com/en/news/91717/hundreds-of-houses-flooded-in-lombok-after-heavy-rain

Lombok Network. (2006, 11 24). *Flash Flood Hit Four Villages in East Lombok*. Retrieved from Lombok Network: http://www.lombok-network.com/lombok_news/flash_flood_east_lombok.htm

The Jakarta Post. (2012, 03 14). *Flash flood hits East Lombok*. Retrieved from The Jakarta Post: http://www.thejakartapost.com/news/2012/03/14/flash-flood-hits-east-lombok.html

Waspada Online. (2010, 09 27). *Flood inundates houses in West Lombok*. Retrieved from Waspada Online: http://waspada.co.id/index.php?option=com_content&view=article&id=145675:flood-inundates-houses-in-west-lombok&catid=30:english-news&Itemid=101

World Weather Online. (2014, 11 21). *Lombok Monthly Climate Average, Indonesia*. Retrieved from World Weather Online: http://www.worldweatheronline.com/Lombok-weather-averages/Nusa-Tenggara-Barat/ID.aspx

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by

Name			
Signature			

Appendix C

Field Mission Details

DAY/DATE	ACTIVITIES	PEOPLE MET
Monday, 1 December 2014		
13.30-14.30	Brief Meeting	World Bank
14.30-15.30	UNESCO	Ardito M. Kodijat – National Programme Officer Disaster Risk Reduction and Tsunami Information
16.00-17.00	Ministry of Public Works on Building Standard	
17.00-18.00	Ministry of Education and Culture	Gogot Suharwoto – Head of Division for Program Planning and Budget Bureau of Planning and International Cooperation
Tuesday, 2 Dec		
06.15-08.05	Depart to Padang	
08.30-13.00	Schools in City of Padang A. Pilot Safe School: SDN 22 Koto Lalang, Lubuk Kilangan B. Damaged Schools SDN 33 and 42 Rawang, South Padang SMP 17 Padang, South Padang SDN 2 Ulak Karang, North Padang SMP 27 Padang, Kuranji	
14.00-16.00	Head of Education Office BPBD Public Works of Kota Padang Head of Religion Office at Kota Padang.	
16.00-18.00	Andalas University	Dr Fauzan – Department of Civil Engineering

DAY/DATE	ACTIVITIES	PEOPLE MET
Wednesday, 3 Dec		
07.10 – 07.30	SDN 23,24 (supported by JICA)	
09.00 – 12.0	Pilot Safe School and Damaged Schools: A. Pilot Safe School: SDN 12 Batang Anai B. SMPN 4 Batang Anai New School supported by AusAid C. Damaged Schools: 1. SDN. 18 Enam Lingkung 2. SMPN. 2 Batang Anai D. Extra School Madrasha	
14.00-15.30	Head of Education Office BPBD Public Works Head of Religion Office at Kabupaten Pariaman	
Thursday, 4 Dec		
09.00 –11.00	AusAID	Joanne Dowling – Unit Manager
12.00-14.00	Ministry of Education and Culture	Mr. Didik and Mr. Jufar Director for Secondary School –
14.00-16.00	Plan International	Wahyu Kuncoro – DRM Program Manager Yusra Tebe – Urban Safe School Coordinator
Friday, 5 December 2014		
09.00-11.00	BNPB on Safe School	Lilik Kurniawan - Director for Disaster Risk Reduction
12.30-13.30	Teddy Boen	Dr Teddy Boen

DAY/DATE	ACTIVITIES	PEOPLE MET
Saturday, 6 December 2014 – North Lombok		
08.00 – 10.45	Damaged Schools at District North Lombok (no pilot school in this district) 1. SDN 4 Malaka (Medium, Flood) 2. SND 1 Bentek 3. SMPN 4 Tanjung (Total Damage, Landslide) 4. SDN 3 Sigar Penjalin, (Total damage, Landslides)	
11.00-13.00	District Education Office BPBD Public Works District Office Religion Affairs District Office at North Lombok	
14.00 – 15.00	SMKN 2 Kuripan, West Lombok Vocational College	Ruju Rachmat - School Principal
15.00 – 17.00	Schools 1. SMPN 1 Narmada (Heavily Damage) 2. SMPN 1 Lembar (Heavily Damage) 3. SDN 4 Jembatan Kembar Timur (Medium Damage)	
Sunday, 7th December		
	Damaged Schools: 1. SMPN 1 Narmada (Heavily Damage) 2. SMPN Negeri 1 Lembar (Heavily Damage) 3. SDN 2 Jembatan Kembar Timur (Medium Damage) 4. SDN 2 Batu Putih (Medium Damage, landslide) 5. SDN 5 Batu Putih 6. SDN 3 Kedaro (Heavily Damage) 7. SDN 1 Kebon Ayu (Heavily Damage , Whirlwind) 8. SDN Telegawaru	

DAY/DATE	ACTIVITIES	PEOPLE MET
Monday, 8 December		
08.00- 09.00	Pilot Safe School SDN 2 Telagawaru in West Lombok District	Ruslan Gani, School Principal SDN 2 Telagawaru
09.00 – 12.00	District Education Office BPBD Public Works District Office Religion Affairs District Office at West Lombok	
Tuesday, 9 Dec		
09.00-12.00	BNPB	Lilik Kurniawan - Director for Disaster Risk Reduction Dr. Raditay Jati – Deputy Director for Disaster Prevention
13.00-16.00	Wrap-up Meeting and Beyond	World Bank

Appendix D

School Visits

D1 List of Schools Visited

Schools Visited Around Padang, Indonesia

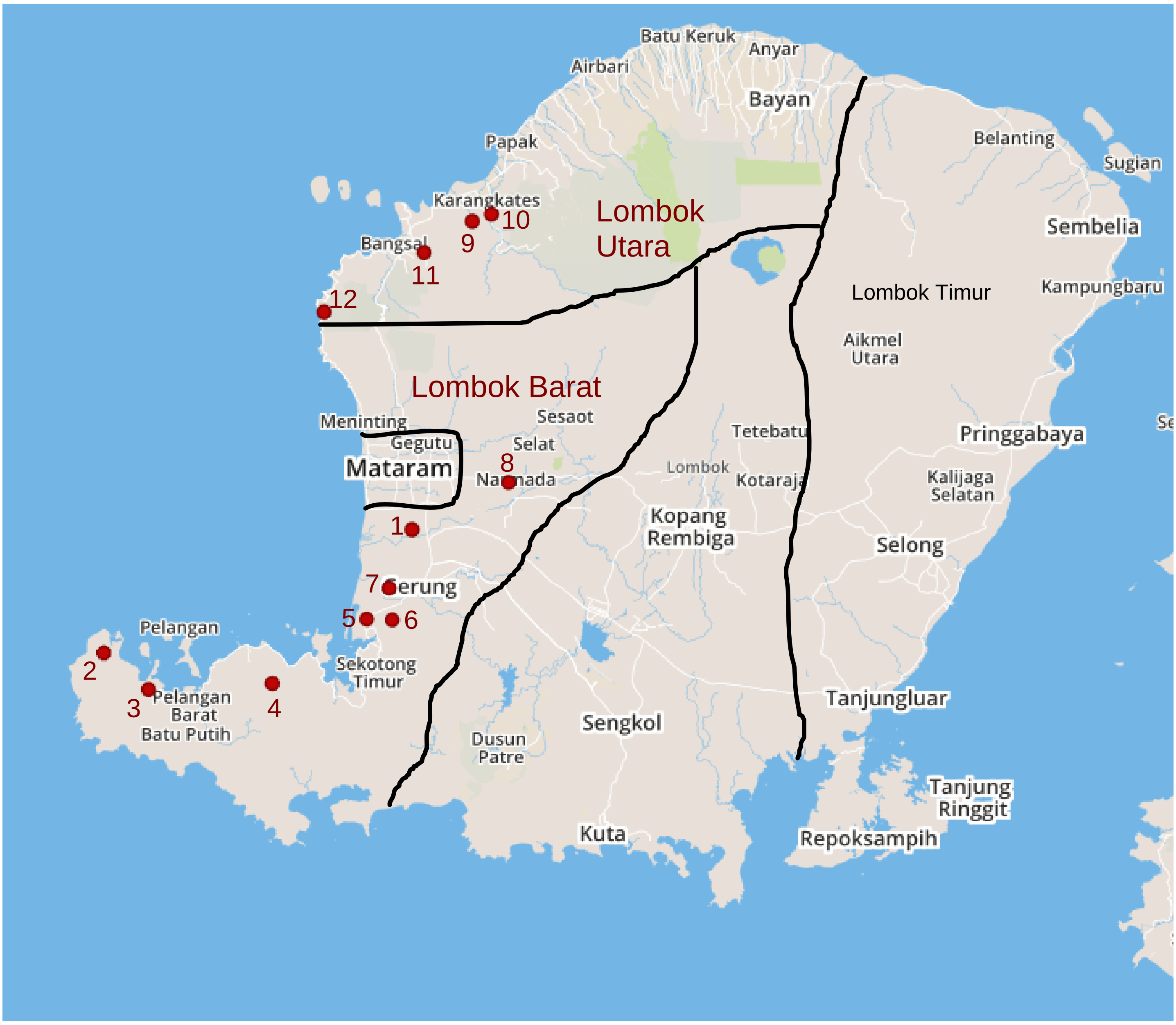
No.	School Name	Photo	Regency
1	SDN 18 Enam Lingkung		Kabupaten Padang Pariaman
2	Madrasha Mean Sintuk		Kabupaten Padang Pariaman
3	SMPN 2 Batang Anai		Kabupaten Padang Pariaman
4	SMPN 4 Batang Anai		Kabupaten Padang Pariaman
5	SND 12 Batang Anai		Kabupaten Padang Pariaman
6	SND 23, 24		Kota Padang
7	SDN 33, 42 Rawang		Kota Padang
8	SMP 17		Kota Padang
9	SDN 22 Koto Lalang		Kota Padang

Map of Visited Schools Around Padang

Schools Visited Around Lombok, Indonesia

No.	School Name	Photo	Regency
1	SDN 2 Telegawaru		Lombok Barat
2	SDN 5 Batu Putih		Lombok Barat
3	SDN 2 Batu Putih		Lombok Barat
4	SDN 3 Kedaro		Lombok Barat
5	SMP Negeri 1 Lembar		Lombok Barat
6	SDN 4 Jembatan Kembar Timur		Lombok Barat
7	SDN 1 Kebon Ayu		Lombok Barat
8	SMPN 1 Narmada		Lombok Barat
9	SMPN 4 Tanjung		Lombok Utara
10	SDN 1 Bentek		Lombok Utara
11	SDN 3 Sigar Penjalin		Lombok Utara
12	SDN 4 Malaka		Lombok Utara

Map of Visited Schools Around Lombok



Selection criteria for school visits for GPSS field mission

1. Primary and Junior High schools that have a construction typology as follows:
   a. Weak Structure (schools which were built during 70s through INPRES Programme)
   b. Schools which have lacked maintenance since the decentralization reform in 1999
2. Schools which are categorized as collapsed, heavy damage, medium damage, and light damage.
3. Schools are located in the potential disaster areas and exemplify the impact of a typical type of disaster (earthquake, flood etc.)
4. Number of students
5. Schools received financial source for rehabilitation/reconstruction or new built schools for 2015

The schools visited are intended to represent typical school infrastructure in Indonesia. Both the unreinforced masonry schools built during the government Inpres programme and the more recent tied masonry schools are likely to be widespread across the Indonesia, although the construction details and quality are likely to vary considerably. Other typologies (concrete moment frame, reinforced masonry, timber, bamboo etc) are likely to occur in the diverse expanse of the country, but these are likely to be localised and specific to particular districts, regions, or islands.

D2 Summary of Findings

School Name	Photo	Location	Regency	Building	Construction Typology	Construction Programme	Year Built	Number of stories	FEMA Scores	Site Exposure	Building Configuration Issues	Falling Hazards	Building Vulnerabilities	Damage	Comments
SDN 18 Enam Lingkung		Padang	Kabupaten Pariaman		Unreinforced Masonry	InPres	1979	1	0.5				Unreinforced masonry is a risk during an earthwuake if not retrofitted		
Madrasha Mean Sintuk		Padang	Kabupaten Pariaman		Confined Masonry	MoRA	1990 with 2005 extension	1	0.5	Site chosen by community	Large openings on long elevation limiting stability system Extension poses a pounding issue at roof level	Brick masonry gable end wall unclear if restrained			
SMPN 2 Batang Anai		Padang	Kabupaten Pariaman	Existing	Confined Masonry	InPres	1985	1	0.5	Physical Planning of the site poses issues of buildings pounding together in an earthquake	Large openings on long elevation limiting stability system.			Observed many cracks in walls in existing buildings from earthquake damage	
				New 2 classroom block under construction		DAK fund	2014				Large openings on long elevation limiting stability system			Observed poor worksmanship during construction i.e. exposed rebar, paper from formwork left in concrete pour, poor masonry construction. Engineering drawings were preent but details (reinforcement) not being followed.	
SMPN 4 Batang Anai		Padang	Kabupaten Pariaman	6 classrooms and offices	Confined Masonry	AusAid through MoEC	2013	1	0.5	Site floods as situated on low lying area that floods during rains. Drainage on site was blocked and not appeared to be maintained or routing water to an appropiate area. No approiate site mitigation measures on site. Land was chosen by District Government because of demand and it was available	Buildings not elevated to avoid flooding. Large openings on long elevation limiting stability system				During the rainy season the school is falsed to close due to flooding (up to 3/4 times per month)
				New 2 classroom block under construction		DAK Funding	2014						Appropiate confined masonry best practice details not being followed in construction (rebar anchorage length)		
SND 12 Batang Anai		Padang	Kabupaten Pariaman	Existing	Confined Masonry		extended 2007	1	0.5	Flooding occurs on site	Where classroom blocks have been extended over time - pounding at roof level poses an issue.				
				New Build (2 classroom block)	Confined Masonry	DAK Funding (Safe School Pilot project)	2012	1	1				Safe School Pilot project facilitators addedd in waist beams under window fram and lintels if span over windows if span greater than 1.5m	Hairline cracks observed in wall panels	
SND 23, 24		Padang	Kota Padang		Concrete Moment Frame	JICA (Tsunami Shelter School)	2011	3 plus shelter on roof	3.3				As-built drawings don't show masonry details therfore it is unclear if detailed inaccordance to sesimic design best practice	no damage observed	
SDN 33, 42 Rawang		Padang	Kota Padang		Confined Masonry	Inpres	1984	2	0.7	School constructed on a floodplain / swamp. Flooding occues regularly during the rainy season and up to 0.5m in depth. Ground floor of school is lower than surrounding land making flooding a risk	Buildings constructed adjacent to each other pose pounding risks	heavy masonry/ concrete spandrels (balconies) on second level - unclear if reinforced	Buildings constructed adjacent to each other pose pounding risks	Settlement observed at ground/ foundatrion level	When the school is flooded school is regularly disrupted
SMP 17		Padang	Kota Padang	New Building (not yet completed)	Confined Masonry	DAK Funding	2014	2	0		Pounding is a risk due to the haphazard planning of buildiongs on site Large openings in wall panels smooth reinforcement used in construction	heavy masonry/ concrete spandrels (balconies) on second level - unclear if reinforced	It is unclear whether there are lintels above the widnows (windows are not at ring beam level)	no damage seen on new building	Contractor left site without finishing work as money had run out Other buidings on site had been damaged in previous earthquakes
SDN 22 Koto Lalang		Padang	Kota Padang		Confined Masonry	DAK Funding (Safe School Pilot project)	2012	1	0.5						

School Name	Photo	Location	Regency	Building	Construction Typology	Construction Programme	Year Built	Number of stories	FEMA Scores	Site Exposure	Building Configuration Issues	Falling Hazards	Building Vulnerabilities	Damage	Comments
SDN 2 Telegawaru		Lombok	Lombok Barat		Unreinforced Masonry with added mesh reinforcement and cornere stiffener columns	Originial School through Inpres Retrofitting funded through DAK (Safe School Pilot Project)	1971 (Retrofit 2012)	1	1			Entrance canopy supported on unbraced concrete columns			
SDN 5 Batu Putih		Lombok	Lombok Barat	Library and classroom	Confined Masonry	DAK Fund	2012	1	0.7	Situated at the base of mountain to suspectible to flooding and landslides Evidence of base of buiulding being eroded and exposing foundations				Cracks in walls at window openings observed	School doesn't have enough capacity. There are 5 classes being taught in one classroom and one library
SDN 2 Batu Putih		Lombok	Lombok Barat	Classrooms	Unreinforced Masonry	Inpres Programme with some repairs undertaken with DAK Funding	1976 with repairs undertaken in 2012	1	0.7		Large window openings limitis stability system in long direction classrooms have been construuction adjacent to eachother which may cause a pounding risk . Classroom on plan L>4b	Low level walls at front of the classroom external corridor may collapse in an earthwuake if not appropiate reinforced and anchored in to columns.	New tiles on walls could cause a risk in earthquakes. High winds blew off roof sheeting in 2013	Cracks and damage to walls observed in original building. Classrooms that been rehabilitated were in much better condition.	Repairs included new ceiling, roof sheeting, floor, and tiles on floor.
SDN 3 Kedaro		Lombok	Lombok Barat	Classrooms	Light Metal Steal Frame	Inpres Programme	1985	1	2.6	The site is in mountains so landslides and flooding is a problem		Ceiling not fixed properly in some places		Generally in poor condition due to ack of maintenance General material detoriation (timber/ metal frame and asbestos panels) Cracks in the asbestos panels Ceiling had fallen down in some areas exposing rusty metal trussess.	Abestos is very brittle material and can be dangerous if disturbed and broken up. Major problem reported at this school was the lack of water - with children sometimes going over a week without a shower. (they have installed rainwater harvesting tanks to help allievate some of the need during the rainy season
SMP Negeri 1 Lembar		Lombok	Lombok Barat	Classrooms	Unreinforced Masonry	Inpres Programme with some repairs undertaken with DAK Funding	1984 (repairs 2014)	1	0.5	Site is exposed to floods from water running of the mountains	Many of the buildings are connected together via covered walkways which could cause a risk of pounding	Roof covered in tiles which pose a risk during an earthquake		Floors are settling due to inadequate buildup under tiles Many classrooms in poor condition due to lack of maintenance including walls, rotten window frames	
SDN 4 Jembatan Kembar Timur		Lombok	Lombok Barat	Classrooms	Confined Masonry	Inpres Programme with some repairs undertaken with DAK Funding	1978 (repairs 2012)	1	0.7	Site exposed to flooding - run off from mountains	Two buildings were built adjacent to eachother causing a risk of pounding during an earthquake at roof level Large opeings in wall compromises the stability of the building	Ceiling not fixed properly in some places and already falling down		Cracks seen in the walls Finishes (ceiling) badly damaged	
SDN 1 Kebon Ayu		Lombok	Lombok Barat	Classrooms	Timber Frame		1949	1	4				Infill masonry walls are not confined or tied to the frame and therefore are a risk in an earthquake	Some of the timber has deteriorated badly Minimal damage observed to plaster on walls and cracks in the floor	
SMPN 1 Narmada		Lombok	Lombok Barat	Classrooms	Confined Masonry	Central Government	1997	2	-0.3		Large window openings limits stability system in long direction classrooms have been construuction adjacent to eachother which may cause a pounding risk . In some buildings there is a soft stroey at ground floor /vertical irregularities in walls casuing a risk to the stability of the buuilding in an earthquake		Unlikely that masonry walls will be anchored in to the concrete frame on the existing classrooms No lintels above large windows in building under construction	Signs of cracking, Evidence of spalling (brick/block/concrete/plaster), Evidence of corrosion Damage to Asbestos ceiling	
SMPN 4 Tanjung		Lombok	Lombok Utara	typical classrooms	Confined Masonry		2005	1	0.7	There is evidence on site of erosion due to flood and water run off. School is constructed next to a river which is prone to flooding	Large window openings limits stability system in long direction		Unsure if the masonry walls have been anchord in to the concrete frame	Many classrooms had cracks in walls (especially around the windows), abestos ceilings that were inadequately fixed properly and were falling down, evidence of leaks in the roof	
SDN 1 Bentek		Lombok	Lombok Utara	typical classrooms	Confined Masonry	Local Government funds	2005 (repairs constructed in 2012) Library constructed 2012	1	0.7		Large window openings limits stability system in long direction on classroom blocks		Unlikely that masonry walls will be anchored in to the concrete frame on the existing classrooms Poor construction workmanship visable in library. Unlikely lintels above large windows	Library severely damaged and no longer in use. (craking in walls, ceiling fallen down)	
SDN 3 Sigar Penjalin		Lombok	Lombok Utara	Classrooms	Confined Masonry	Central government funds (extensions as part of turn key solution)	Original building - 1980 additional extensions 2005	1	0.7	Site cut in to mountains. Severe problems with rain water run off from slope behind the school and sediment building up on back wall and flowing in to classroom.	L>4B Large openings in walls limit stability system	Unreinforced boundary wall at front of school is at risk in flooding and during an earthquake Masonry gable end wall un restrained and poses a risk in an earthquake	Unlikely that masonry walls will be anchored in to the concrete frame on the existing classrooms	Evidence of flooding, signs of water ingress and water damage Ceiling collapsed following earthquake in 2012 Sever cracking in the staff room walls following earthquake	
SDN 4 Malaka		Lombok	Lombok Utara	Library (used a s teachers room)	Confined Masonry	DAK Funds	2012	1	0.7	History of flooding in the site		Elevated water tank constructed next to school building poses a risk in an earthquake (espeically if full of water)			
				Long Classrooms	Confined Masonry	Original school - Inpres programme	Original school building 1982 Other classrooms 2005-2007 were rehabilitated in 2012		0.7		Large window openings limits stability system in long direction on classroom blocks		Unlikely that masonry walls will be anchored in to the concrete frame on the existing classrooms		

D3 FEMA Assessment

FEMA 154 Assessment

To understand the seismic safety of the buildings a FEMA 154 assessment was completed. The process for completing the assessment and the actions taken are summarised in the steps below:

1. An analysis of the Spectral Acceleration at SA = 0.2 and 1.0 sec was completed for Padang and Lombok, Indonesia to determine their FEMA seismicity rating. The USGS Worldwide Seismic Design Tool was used to obtain the SA values for Padang and Lombok. Both location's SA values exceed SA of 0.5g and 0.2g at 0.2 and 1.0 second respectively. Therefore, Padang and Lombok are in regions of high seismicity and the FEMA 154 form for seismicity was used.

Region of Seismicity	SA at 0.2 sec	SA at 1.0 sec
Low	SA < 0.167g	SA < 0.067g
Moderate	0.167g < SA < 0.5g	0.067g < SA < 0.2g
High	SA > 0.5g	SA > 0.2g

Note g = acceleration due to gravity

2. The construction methodology was then used to obtain the base score for each building. Four of the buildings were unreinforced masonry, one was constructed with a concrete moment frame and another used a light metal frame. The most common construction methodology (16) was confined masonry. However, FEMA 154 does not recognise confined masonry and an approximation method was used. The approximation method took an average of the final scores for the construction methodologies which most closely resembled confined masonry[1]: reinforced masonry with flexible floor and roof diaphragms and concrete frame with unreinforced masonry infill. The following table gives a list of the relevant FEMA construction methodologies in the Indonesian assessment and their code labels.

Construction Methodology	FEMA Code Label
Light steel frame	S3
Concrete moment-resisting frame	C1
Concrete frame with unreinforced masonry infill	C3
Reinforced masonry with flexible floor and roof diaphragms	RM1
Unreinforced masonry	URM

3. Building modifiers – the building modifiers are subtracted or added to the base score to obtain the final FEMA score
   a. **Mid/high rise buildings -** none of the buildings surveyed were mid or high rise buildings so no modifiers were used
   b. **Vertical irregularity** – A vertical irregularity is a building that has a soft storey or has part of a storey that does not continue. Three buildings were identified to have vertical irregularities.

[1] Confined masonry buildings have a concrete frame with masonry anchored into the frame.

c. **Plan irregularity** – A plan irregularity is when a building has a non-rectangular shape (unless separated with a gap at the joints) or when a side of the building has large openings over most of the wall. Nineteen buildings were identified to have irregular plans.
d. **Pre/post code** – A modifier was used based on whether or not the building was constructed pre or post building codes. Indonesia uses the American ASCE 7-10 code for buildings which was introduced in 2012. However, ASCE 7-10 does not include confined masonry (the predominant building methodology) and therefore the buildings could have applied to the code. Only one building was built to code, JICA's SDN 23, 24.
e. **Soil Type** –A modifier was used based on the type of soil on site. Both Padang and Lombok had a mix of soil type C (soft rock/dense soil) and D (stiff soil), however, Padang was mostly soil type D and Lombok mostly soil type C.

4. The final scores were then added up.

According to the FEMA 154 version 2 handbook, "Unless a community itself considers the cost and benefit aspects of seismic safety, an S value [safety value] of about 2.0 is a reasonable preliminary value to use within the context of RVS [Rapid Visual Screening] to differentiate adequate buildings from those potentially inadequate and thus requiring detailed review" (FEMA 2002 pg44). A higher FEMA cut-off safety value could be used as it implies a greater desired safety, however, it will increase the community wide costs for evaluation and retrofitting; a lower safety value equates to greater seismic risk but it will lower short term community costs for evaluation and retrofitting. Therefore, a value of 2.0 has been used to determine the seismic safety of the schools assessed.

Only three buildings (JICA's SND 23/24, SDN Kedaro, and SDN 1 0 – highlighted green on the next page) met the 2.0 threshold. This is primarily due to the buildings' construction methodologies not being confined masonry or unreinforced masonry. The remaining buildings had scores 1 or lower with an average value of 0.6. The building with the worse score (-0.3) was SMPN 1 Narmada.

The table below shows the summarized results of the FEMA 154 assessment for the 23 buildings surveyed.

	Number of Buildings	Percent of Buildings
Greater Than 2	3	13%
Less Than 2	20	87%

The table on the following page shows the complete FEMA 154 assessment.

School Name	Location	Regency	Construction Typology	Modifiers										Final Score	
				Base Score	Mid Rise	High Rise	Vertical Irregularity	Plan Irregularity	Pre Code	Post Code	Soil Type C	Soil Type D	Soil Type E	Split	Average
SDN 18 Enam Lingkung	Padang	Kabupaten Padang Pariaman	URM	1.8	-	-	-	-0.5	-0.2	-	-	-0.6	-	0.5	0.5
Madrasha Mean Sintuk	Padang	Kabupaten Padang	RM1	2.8	-	-	-	-0.5	-1	-	-	-0.6	-	0.7	0.5
			C3	1.6	-	-	-	-0.5	-0.2	-	-	-0.6	-	0.3	
SMPN 2 Batang Anai	Padang	Kabupaten Pariaman	RM1	2.8	-	-	-	-0.5	-1	-	-	-0.6	-	0.7	0.5
			C3	1.6	-	-		-0.5	-0.2	-	-	-0.6	-	0.3	
SMPN 4 Batang Anai	Padang	Kabupaten Padang	RM1	2.8	-	-	-	-0.5	-1	-	-	-0.6	-	0.7	0.5
			C3	1.6	-	-	-	-0.5	-0.2	-	-	-0.6	-	0.3	
SND 12 Batang Anai	Padang	Kabupaten Padang Pariaman	Existing - C3	1.6	-	-	-	-0.5	-0.2	-	-	-0.6	-	0.3	0.5
			Existing - RM1	2.8	-	-	-	-0.5	-1	-	-	-0.6	-	0.7	
			SSPR - C3	1.6	-	-	-	-	-0.2	-	-	-0.6	-	0.8	1
			SSPR - RM1	2.8	-	-	-	-	-1	-	-	-0.6	-	1.2	
SND 23, 24	Padang	Kota Padang	C1	2.5	-	-	-	-	-	1.4	-	-0.6	-	3.3	3.3
SDN 33, 42 Rawang	Padang	Kota Padang	C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	
SMP 17	Padang	Kota Padang	C3	1.6	-	-	-1	-	-0.2	-	-	-0.6	-	-0.2	0
			RM1	2.8	-	-	-1	-	-1	-	-	-0.6	-	0.2	
SDN 22 Koto Lalang	Padang	Kota Padang	C3	1.6	-	-	-	-0.5	-0.2	-	-	-0.6	-	0.3	0.5
			RM1	2.8	-	-	-	-0.5	-1	-	-	-0.6	-	0.7	
SDN 2 Telegawaru	Lombok	Lombok Barat	RM1	2.8	-	-	-	-0.5	-1	-	-	-0.6	-	0.7	1
			C3	1.6	-	-	-	-0.5	-0.2	-	-	0.4	-	1.3	
SDN 5 Batu Putih	Lombok	Lombok Barat	RM1	2.8	-	-	-	-0.5	-0.2	-	-0.4	-	-	1.7	0.7
			C3	1.6	-	-	-	-0.5	-1	-	-0.4	-	-	-0.3	
SDN 2 Batu Putih	Lombok	Lombok Barat	URM	1.8	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.7	0.7
SDN 3 Kedaro	Lombok	Lombok Barat	S3	3.2	-	-	-	-	-0.6	-	-	-	-	2.6	2.6
SMPN 1 Lembar	Lombok	Lombok Barat	URM	1.8	-	-	-	-0.5	-0.2	-	-	-0.6	-	0.5	0.5
SDN 4 Jembatan Kembar Timur	Lombok	Lombok Barat	C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	
SDN 1 Kebon Ayu	Lombok	Lombok Barat	W1	4.4	-	-	-	-	-	-	-0.4	-	-	4.0	4.0
SMPN 1 Narmada	Lombok	Lombok Barat	C3	1.6	-	-	-1	-0.5	-0.2	-	-0.4	-	-	-0.5	-0.3
			RM1	2.8	-	-	-1	-0.5	-1	-	-0.4	-	-	-0.1	
SMPN 4 Tanjung	Lombok	Lombok Utara	C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	
SDN 1 Bentek	Lombok	Lombok Utara	C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	
SDN 3 Sigar Penjalin	Lombok	Lombok Utara	C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	
SDN 4 Malaka	Lombok	Lombok Utara	Library - C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			Library - RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	
			Long Classrooms - C3	1.6	-	-	-	-0.5	-0.2	-	-0.4	-	-	0.5	0.7
			Long Classrooms - RM1	2.8	-	-	-	-0.5	-1	-	-0.4	-	-	0.9	

Appendix E

Mission Presentation

GPSS Indonesia

Initial Observations and Recommendations

December 2014

Hayley Gryc & Joseph Stables

6 years compulsory education
9 years compulsory education
Seismic Code (UBC)
MoEC Education Standards
New Seismic Code (IBC/ASCE)
Seismic Code Update (IBC/ASCE)
12 years compulsory education

Decentralisation

1970 | 1980 | 1985 | 1993 | 1997 | 2002 | 2007 | 2010 | 2012 | ?

Inpres School Building Programme

DAK Gov Rehabilitation programme

Building Typologies

- Unreinforced masonry
- Lightweight steel frame / asbestos panels
- (Timber frame)

Building Typologies

- Confined masonry
- Concrete moment frame

Contractor Build

Community Managed Construction

Building Typologies (observed during field mission)

Building Typology	#	Photo	Advantages	Disadvantages
Unreinforced masonry (Inpres programme)	30%		• Easy to build • Durable	• Wall panels unrestrained (No ring beam and / or stiffener columns) • No seismic design
Confined masonry - concrete frame with masonry walls anchored to frame (Government model)	50%		• Seismic resistance if constructed properly and best practice details are followed • Durable	• Large openings compromise stability and do not follow best practice details • Complex rebar detailing
Concrete moment frame with masonry infill panels (e.g. JICA Shelter schools)	10%		• Seismic resistance • Durable • Allows large openings in walls	• Masonry façade may not be tied in • Very complex seismic reinforcement detailing
Timber haunched frame - half height unreinforced masonry walls on raised plinth (e.g. 1940s)	5%		• Lightweight is good for seismic • Easy to build • Quick to build	• Untreated timber susceptible to insect attack and weather degradation • Unrestrained masonry panels
Light steel frame with asbestos shear panels (Empress programme)	5%		• Lightweight is good for seismic performance • Easy to build • Quick to build	• Untreated steel will corrode if not well maintained • Asbestos – issues with damage / removal

Construction Issues

Site Location

- Inadequate consideration given to site selection
- Inadequate mitigation measures in place for hazardous sites
- Inadequate physical planning considerations
- Limited availability of land results in poor site selection

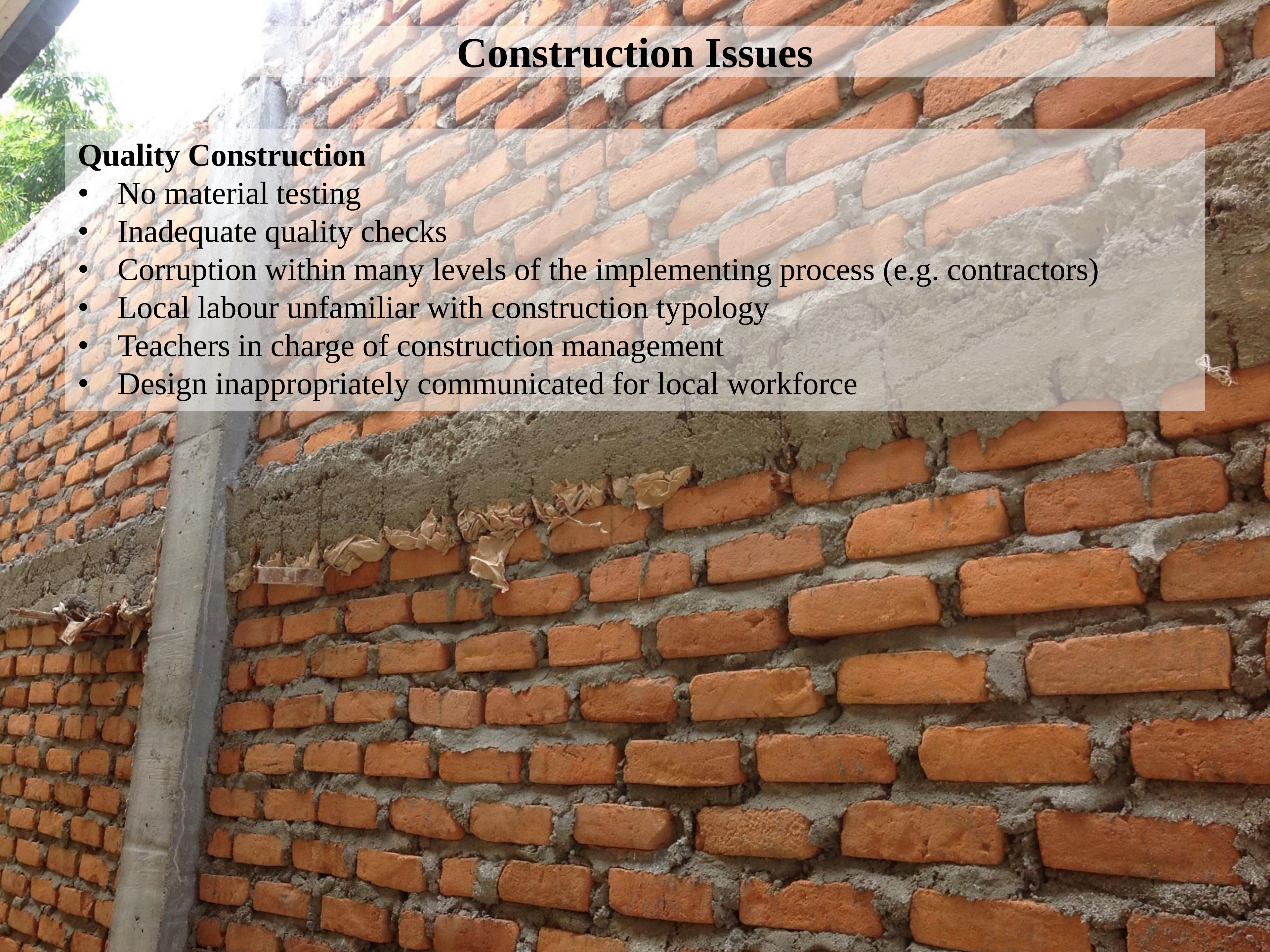
Buildings

- Lack of lintels
- Asbestos ceilings
- Smooth reinforcement is widespread
- Foundations not always adequate
- Roof covering connection to frame can be inadequate for high winds
- Light gauge steel roof frames becoming more popular but connections are not well understood – difficult to fix to, and doesn't support weight of a man for maintenance (but it is good for seismic and more available than timber)

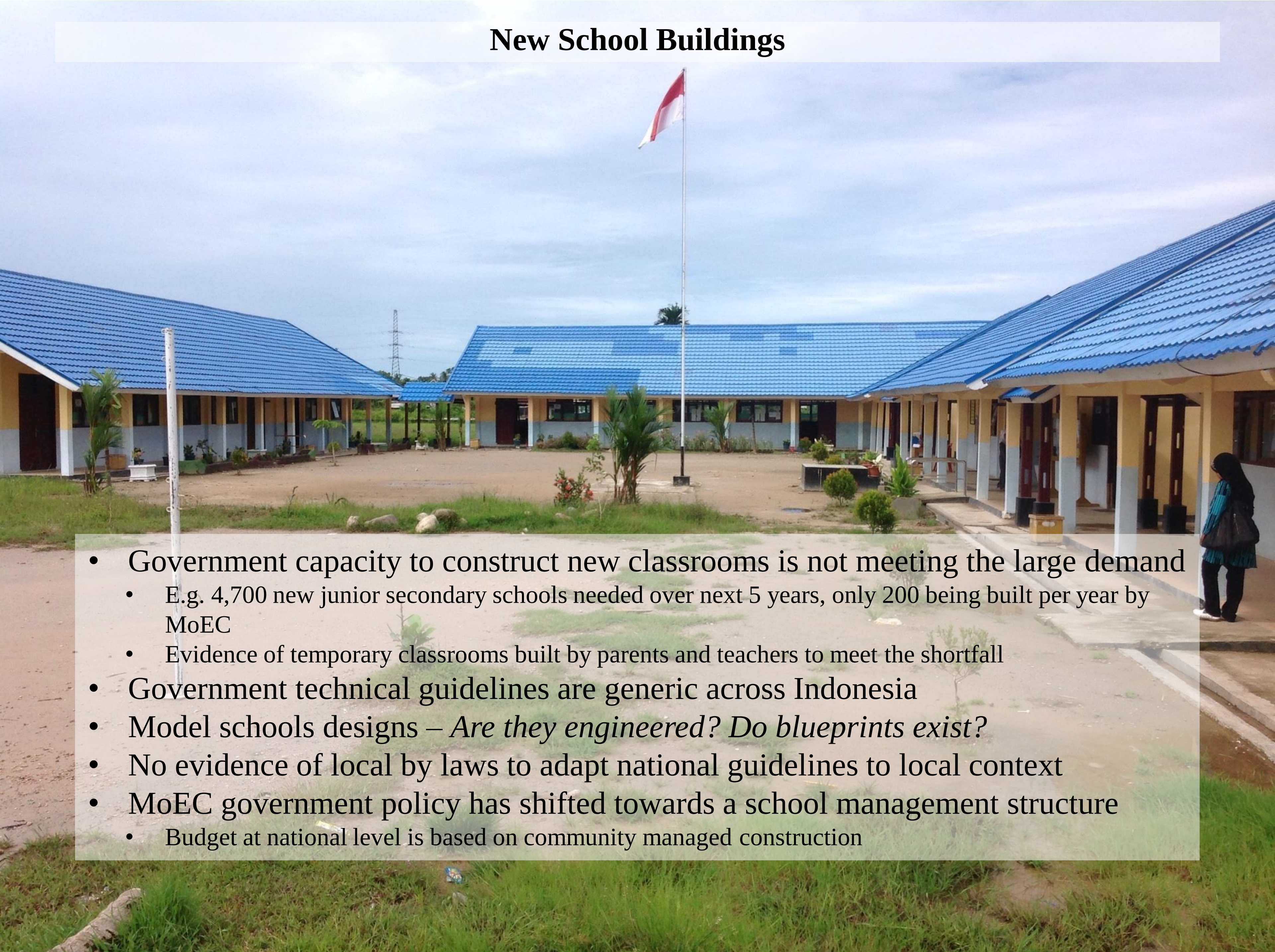
Construction Issues

Quality Construction

- No material testing
- Inadequate quality checks
- Corruption within many levels of the implementing process (e.g. contractors)
- Local labour unfamiliar with construction typology
- Teachers in charge of construction management
- Design inappropriately communicated for local workforce



New School Buildings



- Government capacity to construct new classrooms is not meeting the large demand
  - E.g. 4,700 new junior secondary schools needed over next 5 years, only 200 being built per year by MoEC
  - Evidence of temporary classrooms built by parents and teachers to meet the shortfall
- Government technical guidelines are generic across Indonesia
- Model schools designs – *Are they engineered? Do blueprints exist?*
- No evidence of local by laws to adapt national guidelines to local context
- MoEC government policy has shifted towards a school management structure
  - Budget at national level is based on community managed construction

Existing School Buildings

- Existing schools are vulnerable to hazards due to poor design / construction and maintenance and exposed locations
- Lack of maintenance in the last 30-40 years
- Recent Government rehabilitation fund (DAK) for repair and maintenance Damage assessment to define damage category is based on checklist with each building element weighted
  - Damage categories are percentage of the classroom damage (light, medium, heavy, collapse)
  - Budget is assigned as a percentage of the cost of a new classroom based on a the damage category
  - (Is this methodology appropriate?)
- There is limited understanding of vulnerability of existing schools
  - No mapping of school locations against hazard risks
  - There is no budget for a retrofitting programme
- No baseline criteria for rehabilitation works (typically back to original condition rather than strengthening)

Capacity of Construction Industry

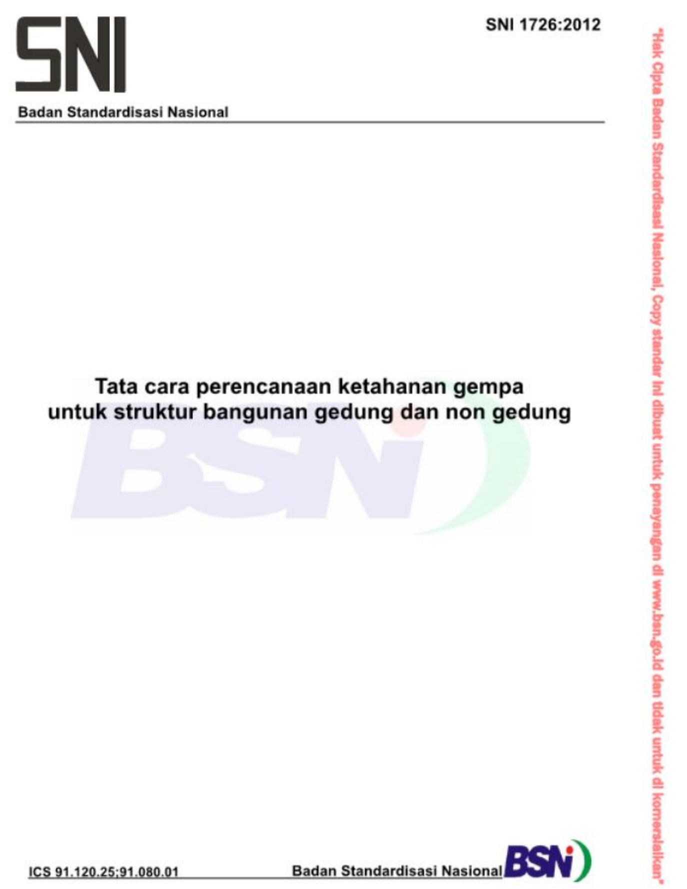
- Safe School construction is not typically included in the curriculum for vocational schools
- Seismic design is taught in Universities, and practising engineers (public and private) are degree qualified
- Professional qualification is only required for signing off drawings by private consultants (not public consultants)

Hazards

- National Government Agencies have develop Nationwide hazard maps (large scale)
- BNPB have developed risk maps based on these hazard maps for disaster management purposes and operational plans (1:250000).
- It is the responsibility of the local government to prepare more detailed hazard/risk maps for each District for spatial planning purposes with guidance from National and Provincial level.
- Local hazard/risk maps have not been created in every District and where they do exist are not necessarily used by the sectors constructing buildings.
- Focus of DRM and safe building practices is on Earthquakes (and Tsunami)
- Limited information on planning and designing buildings for flooding
- More detailed maps are required for site planning and designing safe buildings

Codes and Standards

- MoPW is responsible for writing and enforcing building codes (SNI)
- Updated seismic code 2012 is a direct translation of ASCE 7-10 and is more onerous than previous codes.
  - ASCE 7-10 is a complex code to use
  - ASCE 7-10 does not include confined masonry
- Code is not readily available or enforced
- MoEC has national technical guidelines for school buildings outlining school requirements and referencing building codes. Local by laws are meant to be created for local context, however there was no evidence of this.
  - The technical guidelines were not always available in local government offices
- MoPW (written by Teddy Boen) developed guidelines for seismic details for single storey housing (including retrofitting). These are not regulatory, and not always appropriate for school buildings.
- No Building Codes for flood


SNI
SNI 1726:2012
Badan Standardisasi Nasional

Tata cara perencanaan ketahanan gempa
untuk struktur bangunan gedung dan non gedung

ICS 91.120.25;91.080.01
Badan Standardisasi Nasional BSN

Institutional Environment

- No planning regulations exist
- Building permits are issued by local public works office – limited capacity exist and detailed checks are not normally carried out, especially for single storey buildings
- The local public works office are ultimately responsible for ensuring the quality of construction
  - Consulting engineers are hired to provide construction drawings
  - Supervising consulting engineers are hired to undertake day to day supervision – lack of budget sometimes means there is not enough capacity
  - Public Works office Engineers often take on an administrative role and do not carry out proper checks or manage supervising consultants. In some cases this role is left up to the Education Office to fill (who don't always have Engineering capacity)
- Completion certificates are issued by local public works office
- Certificates are susceptible to corruption
- Lack of coordination between BNPB and other ministries
  - Hazard maps are not used by MoEC, MoPW, or MoRA
- Local Government officials seem to rotate roles, between ministries regularly to avoid corruption
  - Lack of knowledge retention and capacity building within ministries
  - Qualifications/skills are not always appropriate for the role

Implementation of School Infrastructure

1. Ministry of Education and Culture Funds (National)
   - AusAid
2. Special Allocation Fund (DAK) from Ministry of Finance (National)
   - Safe Schools Pilot Programme
3. Endowment Fund from Ministry of Finance
   - Reconstruction following disasters (*no-one has heard of this at district level*)
4. Provincial and District Level Funding
5. Ministry of Religious Affairs (National) funds

Opportunity to develop a National Programme

1. **Design a National Strategic Plan for Safe Schools (NSPSS) to include new construction and retrofit/ repair programme for existing schools**
   - Identify and prioritise where new school buildings are required
     - Develop safe school design and construction guidance/regulations
   - Identify and prioritise most vulnerable schools and whether they require repair, retrofitting or reconstruction
     - Damage and Loss assessments, Rapid Visual vulnerability assessments and Detailed Engineering Assessments.
     - Opportunity to develop VISUS (UNESCO's vulnerability planning tool)
     - Opportunity to utilise the MoEC's Revitalisation Pilot Programme, 2015
   - Streamline the fragmented policy / planning and building regulations associated with schools and direct implementing organisations, community or otherwise, to appropriate approved guidance / regulation

It is recommended that this programme also includes the specific entry point recommendations detailed on the next slide

Recommendations for Entry Points to strengthen existing programmes

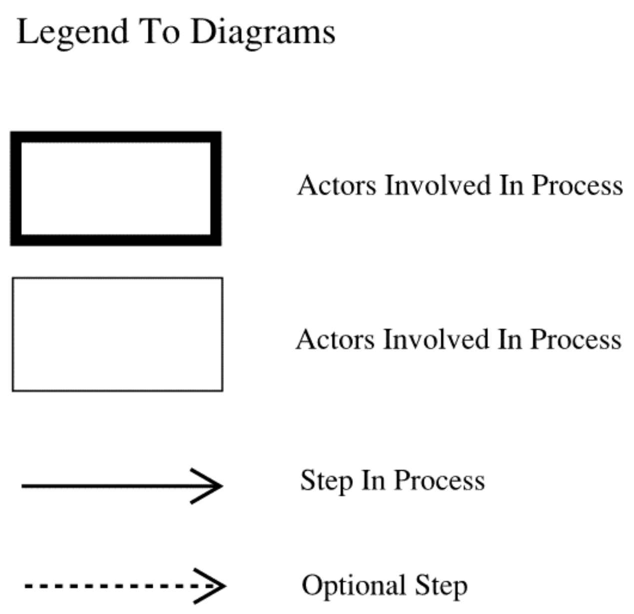
1. **Preparation of more detailed hazard maps for each district to inform the site planning and building design of school infrastructure projects**
2. **Improve quality and reduce vulnerability of DAK funded schools (rehabilitation)**
   - Repair and retrofitting guidelines specific to existing school typologies
   - Develop guidance on QA (Quality Assurance) processes to be undertaken during planning and construction
3. **Reduce vulnerability of new construction**
   - Review and Value engineer existing Government model designs
   - Develop a strategy for each Province to include;
     - Adaptable model school engineered design blueprint, including typical foundation options
     - Include site selection and planning guidelines
     - Communicate design and construction information in accessible format for local labour force
     - Develop local By-laws to enforce model designs
4. **Develop capacity and capability of supervising consultants (and facilitators)**
   - Introduce Safe School Construction into curriculum for all vocational schools
   - Training for trainers to be developed
     - Potential to coordinate with the National Association of Indonesian Engineering Consultants (INKINDO) and/or university institution

Appendix F

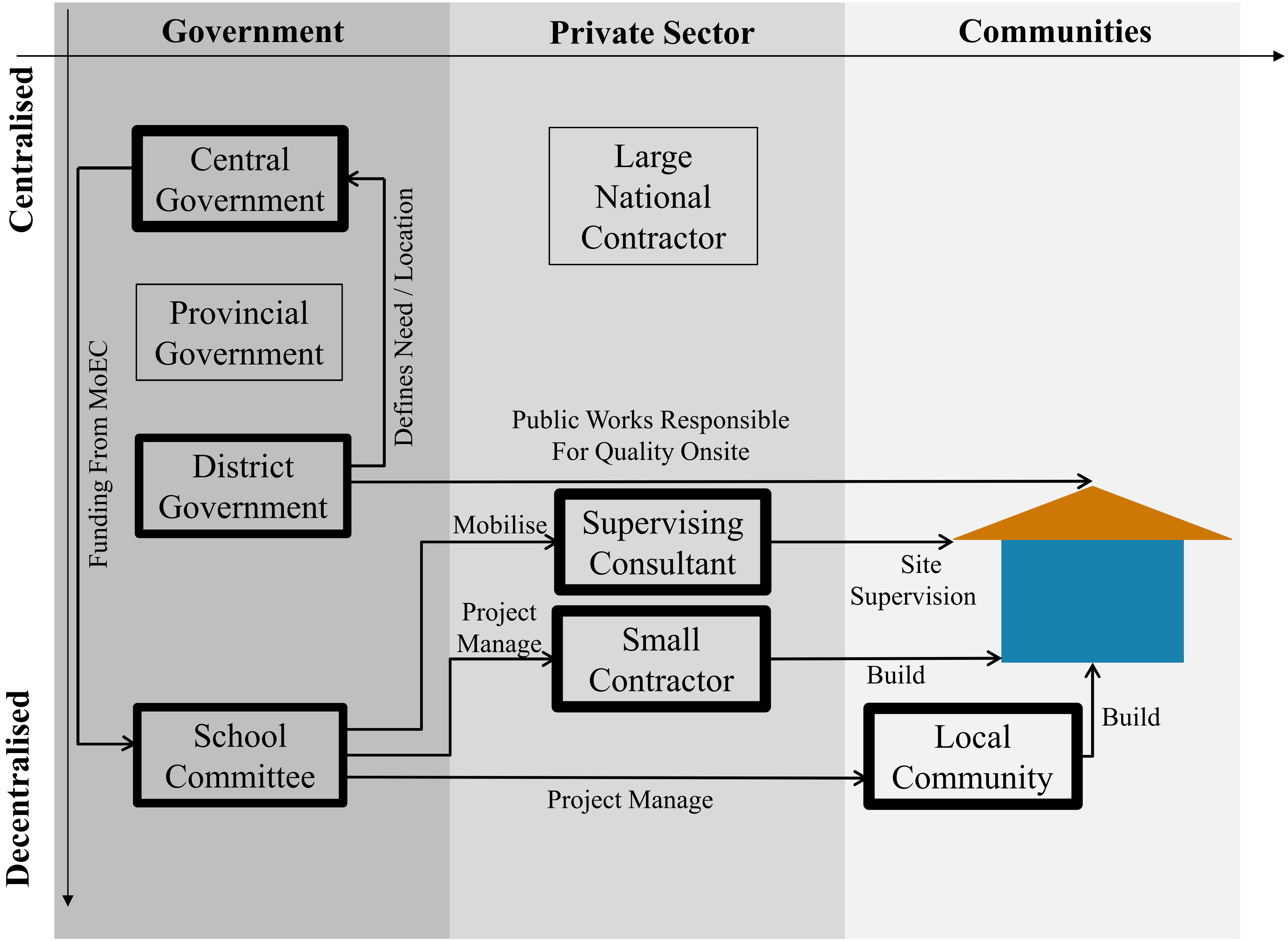
Funding Streams

Implementation stream diagrams

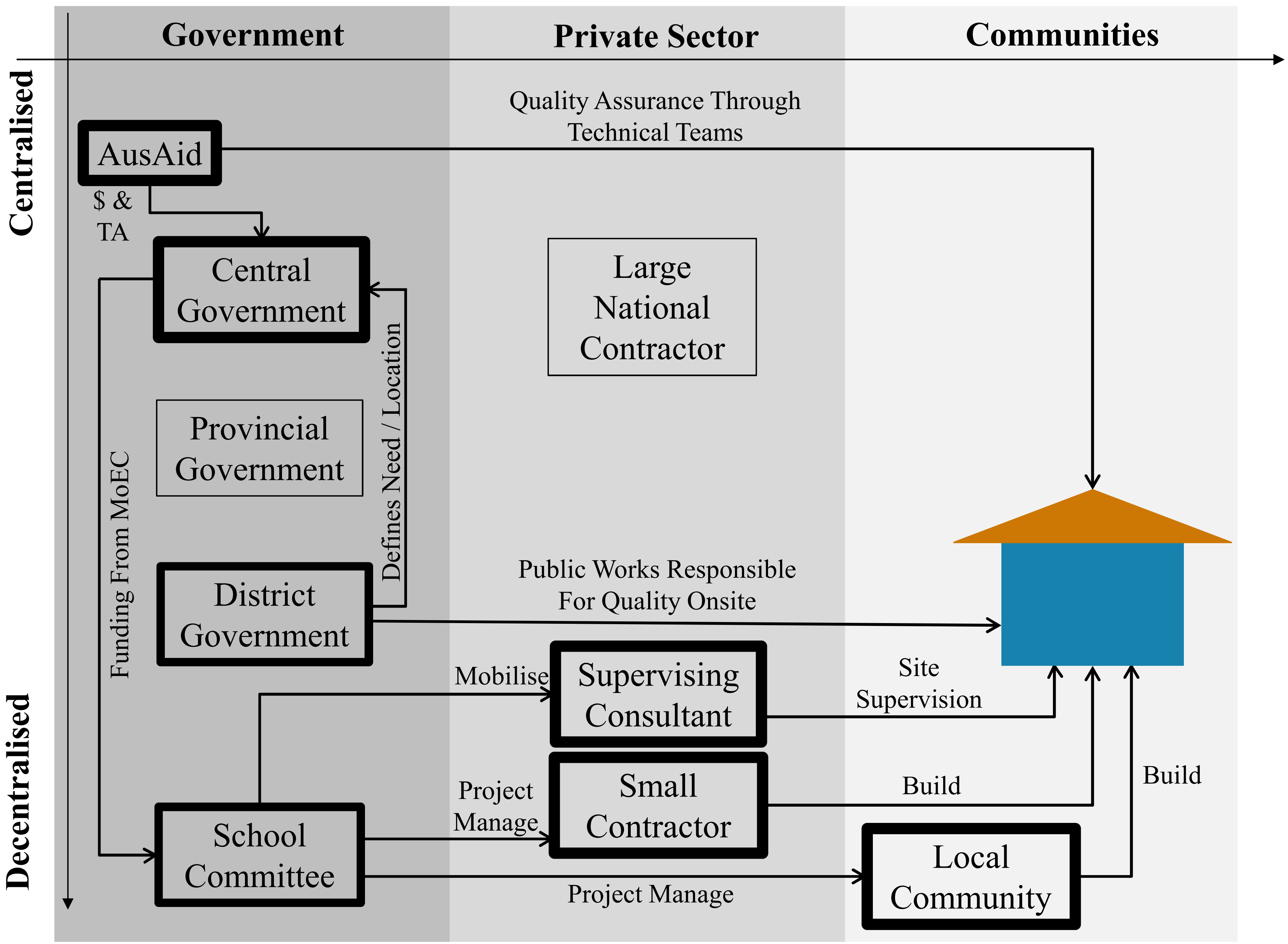
The diagrams on the following pages illustrate the responsibilities of the parties involved in the implementation of school infrastructure. The legend to the diagrams is below.



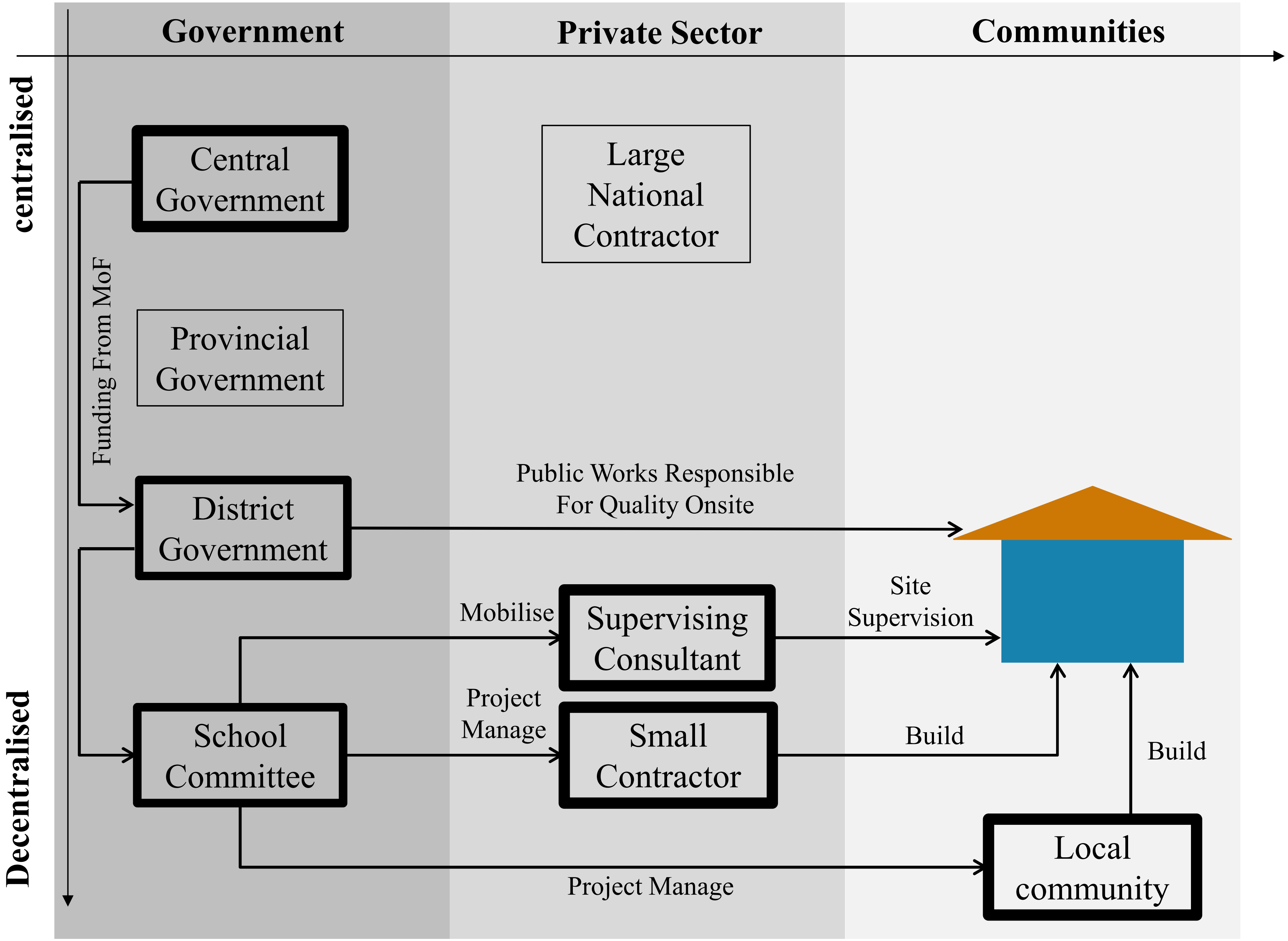
1. MoEC FUND – Central Funds



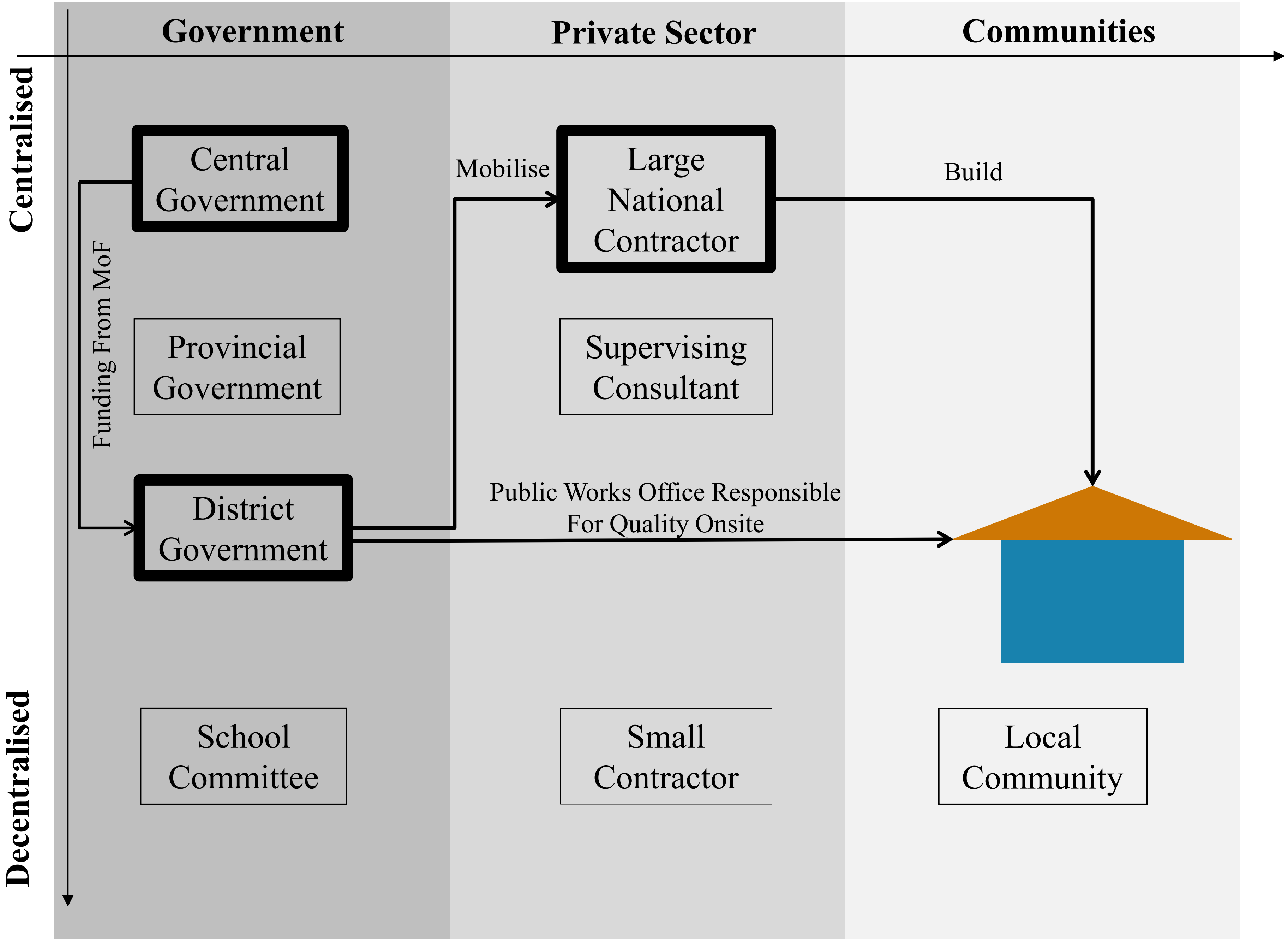
1. MoEC FUND – Central Funds (Including AusAid – 1150 Schools)



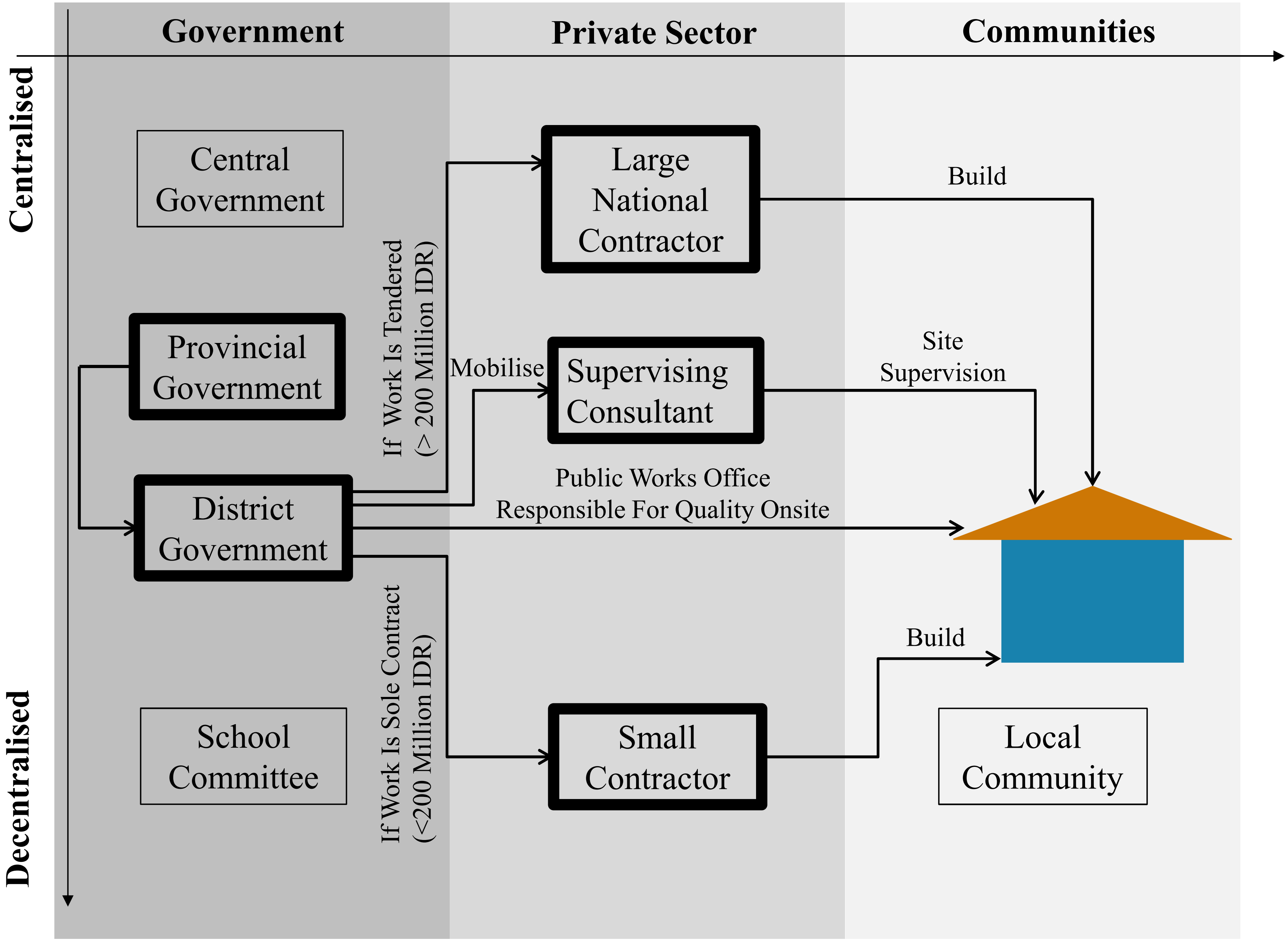
2. Special Allocation Fund - DAK



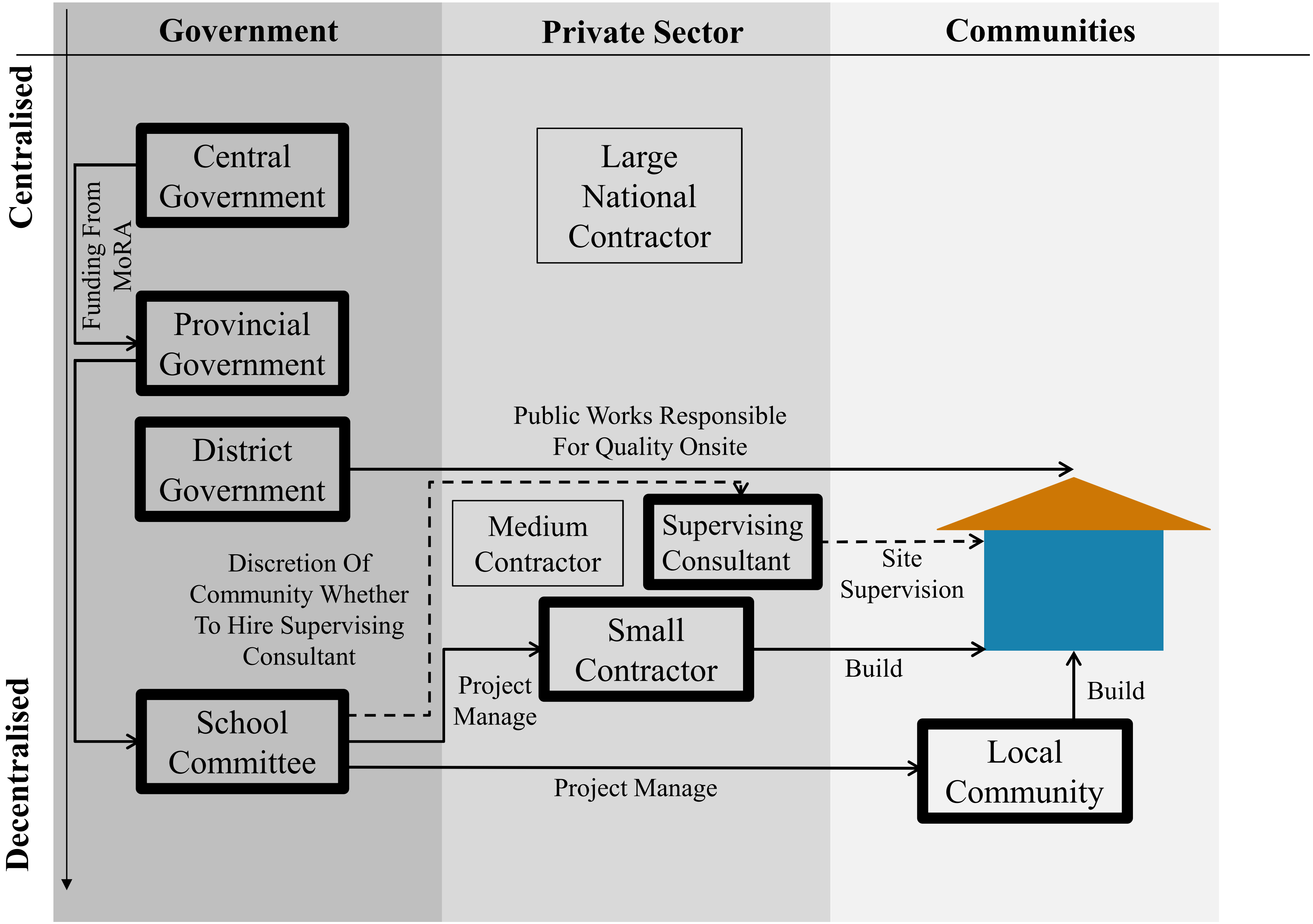
3. Endowment Fund



4. Local Funds



5. Madrasah



Government
Private Sector
Communities
Centralised
Decentralised
Central Government
Funding From MoRA
Provincial Government
District Government
Large National Contractor
Public Works Responsible For Quality Onsite
Medium Contractor
Supervising Consultant
Site Supervision
Discretion Of Community Whether To Hire Supervising Consultant
Small Contractor
Project Manage
Build
Build
School Committee
Project Manage
Local Community

Appendix G

Arup comments on WB publication "Making Schools Safe from Natural Disaster"

From: Jo da Silva
Sent: 28 November 2014 17:35
To: 'Iwan Gunawan'
Cc: Abhas K. Jha; Inneke Herawati Ross; Demilour Reyes Ignacio; Rinsan Tobing; Yulita Sari Soepardjo; Vica Rosario Bogaerts; Niels B. Holm-Nielsen; Samer Al-Samarrai; Fernando Ramirez Cortes; SUR GP All Staff; EASHD
Subject: RE: Invitation – Virtual Technical Review of: Practical Guideline for Making Schools Safe from Natural Disaster (18 November 2014)

Dear Iwan

Thank you for the opportunity to review and comment on this publication. Please feel free to discuss my comments next week with Hayley and Joseph. I am sorry that I am not able to be there myself.

a. **Appropriateness**.

- The target audience is school principals and staff, who have responsibility for construction, operating and maintaining schools. I suggest they need to:
    i. Be aware of the factors that contribute to their vulnerability to natural disasters (exposure, location, school buildings etc);
    ii. Understand their responsibilities with respect to safe schools, and the support (technical and financial) available;
    iii. Be able to plan, implement and monitor a programme of activities to make their schools safe – or at least, safer.

  This publication addresses all 3 topics, but seems to focus mostly on iii. Is this the right balance?

- The target audience will not have a technical or construction background. Therefore, I suggest that all technical information (eg. p20-27) is moved to the Appendix. It should be clear that technical expertise will be needed for implementation of structural aspects including carrying out assessments, certainly to design retro-fitting programmes, or oversee construction of new buildings.
- I found Chapter 2 confusing as the sub-headings duplicate the main chapter headings (e.g. Section 2.2 repeats Chapter 1). I suggest that having defined a 'Safe School' in Indonesia (section 2.1), this chapter focuses on how this can be achieved strategically through a combination of structural and non-structural activities. It might be helpful to refer to the 3 pillar framework in *Comprehensive Schools Safety Framework* (attached).
- There are not necessarily 'simple ways' to make ageing school buildings safe (p18). I think you mean, there are simple ways to assess whether school buildings are safe.

- It might be clearer if section 3.1.3 was titled Structural Aspects and 3.1.4 Non-Structural aspects with sub-sections that aligned more closely aligned with the six structural/non-structural aspects cited in 3.1.2.

b. Completeness/Sufficiency

- The publication applies to one-storey buildings (or classrooms) only. Previously (in 2005) these did not have to comply with the requirements of the Indonesian building code. Is this still the case? What buildings standards are applicable (p39)?
- Previously, the technical plans and specifications provided by Government did not necessarily incorporate seismic design requirements for safe schools? Do they now? And, are they now in a format that school principals, local contractors and individuals overseeing construction can understand? Annex 4 provides a specification (or scope of works or project brief) but is not a 'detailed technical specification' that includes the quality of design, materials and workmanship for ensuring quality construction.
- It focusses primarily on vulnerability to earthquakes, and many items in the checklist in Annex 1 p52-63 relate specifically to earthquakes. Other hazards (flooding, drought, landslides, fire) are mentioned but not the measures that can be taken to mitigate these risk – particularly at site level (drainage, retaining walls, vegetation etc.). Please see Arup report (attached).
- There is a lot of repetition in the information in Annex 1 p 54-73. It would be more useful is condensed and presented as a checklist for schools principals, staff, parents or engineers employed on their behalf a) assessing existing schools and b) constructing new schools. P59 needs to be clear that reinforced must be deformed (ribbed) bars not plain (smooth) bars.
- It's not clear where the recommendations in Annex 2 come from or how it is intended they are used. They cover actions that impact on normal health & safety requirements for buildings (eg. handrails) as well as for natural disasters which is perhaps confusing.
- The BoQ in Annex 3 appears to be for new construction though referenced on p33 as relating to retrofitting. Likewise Annex 4.
- The safe school assessment tool in Annex 6 is appropriate for operational safety of occupants but not appropriate for assessing structural safety, particularly in seismic areas. For this, various rapid visual assessment methods are available that could be adapted for this context.

c. Presentation

- It is nicely presented with a good balance of text, graphics and photographs. It is in English and probably needs to be translated.
- I am not sure how much value the Appendices add in their current form. A set of checklists might be more useful to the target audience, or references to other publications for further reading.
- A document of about 30 pages (excl. Appendices) is digestible. However, it might it be even more accessible if packaged as a Powerpoint training Module I: Introduction to Making Schools Safe from Natural Disaster. Additional modules focussing more specifically on Assessment of School Buildings, or Developing a Safety Management Plan could be developed subsequently.

Warm regards

Jo

Jo da Silva
Director | Arup International Development

Arup
13 Fitzroy Street London W1T 4BQ United Kingdom
t +44 20 7636 1531 **d** +44 20 7755 2010
f +44 20 7755 2607 **m** +44 7747 762 615
twitter @ArupID
www.arup.com/internationaldevelopment