Risk Assessment:

Hazardous Water Resource Area in Bali, Indonesia from Mt. Agung Volcano Eruption using 30-meter resolution LiDAR DEM's

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GEO 327G

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Introduction

Since August, 2017, Mt. Agung in Bail, Indonesia has been showing signs of volcano eruption which also last occurred in year 1963 & 1964 and caused thousands of deaths. As the sign of eruption became more significant, Indonesia's disaster mitigation agency had raised the alert to the highest level four on Bali's Mt. Agung volcano and warned residents in 8-10 km radius around the volcano to evacuate immediately. (http://news.abscbn.com/overseas/11/27/17/indonesia-raises-alert-to-highest-level-4-on-bali-volcano)

Many hazard assessments on lahar and tephra have been done, however, there has not been many researches on water pollution assessments. Indonesia is the fourth most populous country in the world with 258 million inhabitants. However more than 27 million Indonesians lack safe water, and 51 million lack access to improved sanitation facilities.

(https://water.org/our-impact/indonesia/)



(https://water.org/our-impact/indonesia/)

The goal of this project is to provide assessment where there might be a water pollution caused by ashes in Bali, Indonesia using 30-meter resolution LiDAR DEM data. To do this, we need to identify all residential areas water streams and how far ashes will blow. Environmental factors and administrative factor such as wind, weather and location of water treatment plant are important factors to consider however due to lack knowledge, these factors will be neglected.

Data Collection

The following files were collected for this assessment.

Layer	Source	Description	File
Name			Туре
DEM	USGS: ASTER Global Digital Elevation Model V002	The data are posted on a 1 arc-second (approximately 30–m at the equator) grid and referenced to the 1984 World Geodetic System (WGS84)/ 1996 Earth Gravitational Model (EGM96) geoid. https://gdex.cr.usgs.gov/gdex/	Aster
	National	The text files contained lat., long., full name of the city, etc.	
Populated	Geospatial-	http://geonames.nga.mil/gns/html/namefiles.html#I	Text
Places	Intelligence		
	Agency		

Table 1: Information on collected data

Data processing

Preprocessing

1. Change symbology

-DEM's properties

– For better view of elevation, I classified the elevation with interval size of 20m and

excluded value of 0 for future usage creating contour line. (Figure 2)

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	Classification Defined Interva	Classes	Classify
	Color Ramp		~
	Symbol Range	Label	~
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	20 - 40	21 - 40	
	40 - 60	41 - 60	
	60 - 80	61 - 80	
- 1 - 1 - 1 - 1	80 - 100	81 - 100	
- A.	100 - 120	101 - 120	~
	Show class breaks using ce	ill values Displ	ay NoData as
bout symbology	Use hillshade effect	Z: 1	

Figure 1: Properties of DEM layer



Figure 2: Classification properties of DEM layer

2. Create hillshade

-Hillshade (Spatial Analyst – Surface)

-z factor's default value was 1 but changed it to 0.000009 (Figure 3)

🔨 Hillshade	\times
Input raster	~
DEM 🗹 🖆	
Output raster	
\\austin.utexas.edu\disk\geoprofiles\default\sb54778\My Documents\ArcGIS\Default.gdb\HillSha_tif2	
Azimuth (optional)	
315	
Altitude (optional)	1
45]
Model shadows (optional)	
Z factor (optional)	
0.00009	
OK Cancel Apply Show Help >	·>

Figure 3: Creating a hillshade raster using hillshade tool

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- 3. Create contour line for coastline
 - Raster Calculator (Spatial Analyst Map Algebra)
 - True value was set to greater than 1 to differentiate inland from seawater. (Figure 4)

🔨 Raster Calculator				— 🗆	\times					
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 ♦ fill_sink ♦ pjt_raster ♦ aster_hsd_1 ♦ 20171128114015_428230752 	*	4 5 6 1 2 3 0 .	* > >= - <	SetNull Math Abs Exp Even10						
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		ОК	Cancel Environ	ments Show Help >	>					

Figure 4: Create binary feature using raster calculator



Figure 5: Polygon shapefile of Bali Island

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4. Project raster into appropriate coordinate system

- Project Raster (Data Management – Projection and Transformation - Raster)

- To: Indonesian_1974_UTM_Zone_50S

~	, Project Raster		\times
l	Input Raster	_	~
	DEM	2	
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	GCS_WGS_1984	*	
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	Indonesian_1974_To_WGS_1984_3	+ ×	~
	OK Cancel Apply Show H	∎ Help >>	•

Figure 6: Changing raster's coordinate system

ArcHydro

In this section, I used hydrology tool to take the DEM and created stream water flow based on flow accumulations from flow directions. This is a very powerful tool when you don't have inland water raster data. To get the data using hydrology tool, following steps were proceeded:

1. Fill

- Fill (Spatial Analyst – Hydrology)

- Most DEMs have artificial gaps, or pits, from when they were first created. The cells that make up a pit have no downstream cells around it, so unless these pits are filled, they will become sinks and will isolate some portions of the watershed and will influence their flow accumulations. It is important to produce a new DEM that will fill these pits by increasing the elevation of the pour point until that pit will drain to neighbor.



(http://www.geo.utexas.edu/courses/371c/project/2016F/Munoz_GIS_Project.pdf)



Figure 8: Creating new DEM raster using fill tool

2. Flow Direction

- Flow Direction (Spatial Analyst – Hydrology)

- Flow direction of the raster cells are created using the accumulation of directions of lowest neighbors adjacent to a raster cell. The flow direction raster will look like the raster shown below, with an 8 value raster table with the values, 1,2,4,8,16,31,64, and 128. These numbers correspond to the flow direction explained below.



Figure 9: Principle of flow direction tool Risk Assessment: Hazardous Water Resource Area in Bali, Indonesia from Mt. Agung Volcano Eruption using 30-meter resolution LiDAR DEM's | Bang, Su Young

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≪ Flow Direction					\times
Input surface raster					^
fill_sink				🖃 🔁	
Output flow direction raster					
G:\project\flow_direct				2	
Force all edge cells to flow outward (optional)				
Output drop raster (optional)					
					\sim
	ОК	Cancel	Apply	Show Help >>	

Figure 10: Creating flow direction raster

- 3. Flow Accumulation
 - Flow Accumulation (Spatial Analyst Hydrology)
 - Raster of the accumulations of the flow directions.

Flow Accumulation				—)	\times
Input flow direction raster						~
flow_direc				-	6	
Output accumulation raster						
G:\project\flow_accum					2	
Input weight raster (optional)						
				-	2	
Output data type (optional)						
INTEGER					\sim	
						\sim
_						
	OK	Cancel	Environments	Show I	Help >>	•

Figure 11: Creating flow accumulation raster (*output data type was changed to integer)

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Figure 12: Portion of flow accumulation raster

4. Masking flow accumulation raster into Bali Island polygon

- Extract by Mask (Spatial Analyst – Extraction)

Input raster flow_accu_in Input raster or feature mask data bali_polygon Output raster G:\project\water_mask	<
flow_accu_in Imput raster or feature mask data bali_polygon Imput raster Output raster G:\project\water_mask	~
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bali_polygon Image: Comparison of the second seco	
Output raster G: \project\water_mask	
G:\project\water_mask	
	5
OK Cancel Environments Show Help >>	

Figure 13: Masking flow accumulation raster to Bali Island

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5. Stream Raster

- Raster Calculator (Spatial Analyst Map Algebra)
- Any flows with greater value than 2000 was considered as stream.

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Figure 14: Creating stream raster using raster calculator tool

- 6. Stream Polyline Feature
 - Stream to Feature (Spatial Analyst Hydrology)
 - This tool was used to separate stream raster into individual polylines.

🔨 Stream to Feature				_)	~
Input stream raster							~
flow_direc					•	6	
Input flow direction raster							
flow_direc					-	6	
Output polyline features							
G:\project\stream_feature1.shp						1	
Simplify polylines (optional)							~
	ОК	Cancel	Environments	. Sl	how H	elp >>	

Figure 15: Creating polyline feature of stream raster using stream to feature tool



Figure 16: water stream polyline created from flow accumulation raster

Populated Place

This part contains creating a buffer zone from Mt. Agung, loading populated places data,

clipping data to buffer zone.

1. Mt. Agung

- Go To XY & Convert Graphics to Features

- Located a point at 115.507, -8.343 Decimal Degrees as a Mt. Agung. And converted the

graphic data to feature data.

Convert Graphics To Features	\times
Convert:	
Point graphics \checkmark	
Selected graphics only	
Use the same coordinate system as:	
• the data frame	
◯ this layer's source data:	
🚸 population_clp	-
 the feature dataset you export the data into (only applies if you export to a feature dataset in a geodatabase) 	
\bigcirc the annotation groups in this data frame	
Output shapefile or feature class:	
G:\project\Poing_MTshp	2
Automatically delete graphics after conversion	
About converting graphics OK C	ancel

Figure 17: Converting graphic data of Mt. Agung into feature data

2. Create Buffer Zone

- Buffer (Analysis – Proximity)

- Created 2 buffer zone. 12km buffer zone is created because the Authorities imposed

12km exclusion zone and issued highest level of alert following hundreds of tremors

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and signs of magma rising to surface. 60km buffer zone is created because 20~30cm of volcanic ash rained in some parts of Bali that were 70km away from Mt. Agung in year 1964. However, experts expect this volcano eruption to be smaller than the one in year

1964. Therefore, the distance was reduced to 60km rather than 70km.

(http://www.news.com.au/travel/travel-advice/health-safety/everything-you-need-to-know-about-the-volcanic-ash-cloud/news-

story/9e57189b4bcccbc8f54886f470719f9e)

🔨 Buffer				—			×
Input Features							~
Poing_MT					-	6	
Output Feature Class							
G:\project\`12km.shp						2	
Distance [value or field] Linear unit							
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◯ Field							
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Side Type (optional)							
FULL						\sim	
End Type (optional)							
ROUND						\sim	
Method (optional)							
PLANAR						\sim	
Dissolve Type (optional)							
NONE						\sim	$\mathbf{\vee}$
Dissolve Field(s) (optional)							
	ОК	Cancel	Enviro	onments	Show H	Help >>	•

Figure 18: Creating 12km Buffer zone from Mt. Agung

Tanut Factoria						
Poing MT				-	*	1
Output Feature Class						
G:\project\60km.shp					P ³	
Distance [value or field] () Linear unit						
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Dissolve Type (optional)						
NONE					\sim	
Dissolve Field(s) (optional)						

Figure 19: Creating 60km Buffer zone from Mt. Agung



Figure 20: Display of 12km and 60km buffer zone from Mt. Agung

- 3. Populated Places
 - Initial text file data contained 300858 populated places in Indonesia.
 - Using excel, all the populated places in Indonesia was brought to ArcMap and the data

was clipped to Bali Island polygon.



Figure 21: Clipping populated places in Indonesia to Bali Island polygon



Figure 22: Populated Places in Bali Island

4. Eliminate Duplicates

- Delete Identical (Data Management – General)

- Original file contained many identical points. Using Military Grid Reference System value, where different point cannot share same value, duplicate points were deleted. The number of points were reduced to 4590.

🔨 Delete Identical	- 🗆 X
Input Dataset population_clp	
Field(s) Field(s) RC UFI UIFI LAT LONG DMS_LAT DMS_LONG MGRS	
Select All Unselect All XY Tolerance (optional) Z Tolerance (optional)	Add Field Decimal degrees 0
OK Cancel	Environments Show Help >>

Figure 23: Deleting same points

5. Populated places in 12km buffer zone and 60km buffer zone

- Clip (Analysis – Extract)

- The number of populated places in 12km buffer zone was 250.

🔨 Clip							\times
Input Features							~
population_clp					-	6	
Clip Features							
12km					-	6	
Output Feature Class							
G:\project\population_12.shp						6	
XY Tolerance (optional)							
				Decimal deg	grees	\sim	
							\sim
	ОК	Cancel	Enviro	onments	Show H	Help >:	>

Figure 24: Clipping populated places to 12km buffer zone

- The number of populated places in 60km buffer zone was 4036.

🔨 Clip				_		2	\times
Input Features						-*	^
population_clp					-		
Clip Features							
60km					-	6	
Output Feature Class							
G:\project\population_60.shp						B	
XY Tolerance (optional)							
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	OK	Cancel	Enviro	nments	Show H	lelp >>	•

Figure 25: Clipping populated places to 60km buffer zone



Figure 26: Display of populated places in 12km buffer zone (green) and 60km buffer zone (red)

6. Polluted Water Stream

- Select By Location

Select By Location	\times
Select features from one or more target layers based on their location in relation to the features in the source layer.	
Selection method:	
select features from	\sim
Target layer(s):	
<pre>population_12 population_60 population_dp 12km 60km Ø stream_feature Poing_MT bali_polygon balicontour</pre>	
Only show selectable layers in this list	
Source layer:	
₩ 60km	-
Use selected features (0 features selected)	
Spatial selection method for target layer feature(s):	
are within a distance of the source layer feature	\sim
Apply a search distance	
100 Meters ~	
About select by location OK Apply Close	

Figure 27: Selecting water streams that are within 60100 meters from Mt. Agung

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Conclusion

Indonesia's less developed water sanitization system and high ratio of people who uses open water tank in Bali Island tells that heavy ash falls and magmas are not the only threat to the people living in a small village near Mt. Agung.

Due to lack of sufficient data of actual number of people living in each village, accurate number of population who are at risk of heavy ash fall and exposed to contaminated water was not able to be calculated. However, approximate number of populated places that are at risk are listed below. (Table 2)

# of Populated Places in Bali Island	4590
# of Populated Places within 12km from Mt. Agung	250
# of Populated Places within 60km from Mt. Agung	4036

Table 2: Result of number of Populated Places

There is no doubt that people living within 12km from Mt. Agung should be immediately evacuated and draw more attention, however, the people living 50~70km should also be immediately informed and be award of the fact that they are also at risk from ashes blowing from the volcano end up contaminating their water resources.

Final Map



Risk Assessment: Populated Places At Risk of Heavy & Small Ash Fall

Coordinate System: Indonesian_1974_UTM_Zone_50S Datum: D_Indonesian_1974 Units: Meter

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