

2018

PALU

INDONESIA

A land suitability

CASE STUDY

Indonesia

Due to the fast-pace rhythm at which urban population is growing in Indonesia, the incorporation of data-driven analytics into urban planning, as well as policy and investment decision-making are of utmost relevance.

Projections estimate that urban population in Indonesia will increase from 56% in 2018 to 71% in 2050 [1]. Urbanization brings with it increased accessibility to services, and more economic opportunities, as can be seen in other countries in the region. However, due to a deficit in urban infrastructure, slow gains in labor productivity, high inequality and important shortages of affordable housing in Indonesia, the potential benefits of urbanization, such as growth and poverty reduction are being inhibited [2].

[1] World Bank Group, [World Bank data, 2017](#)

[2] World Bank Group, [National Affordable Housing Program in Indonesia](#), June 2015



78.8 million new urban dwellers

Population in Indonesian cities is expected to increase from 149 million inhabitants in 2018 to 228 million inhabitants in 2050 [2]. This represents an increase of 7.78 million urban dwellers, or roughly 2.5 times the population of Jakarta Metro Area.

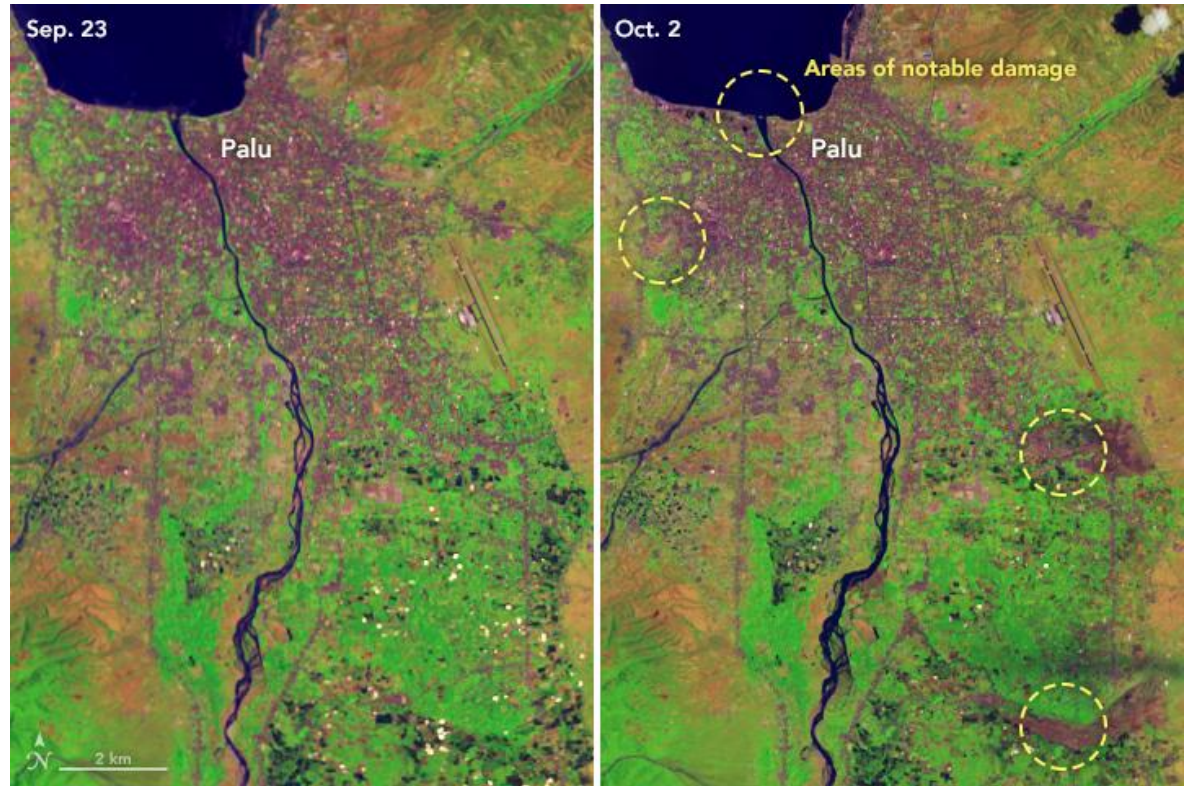
Introduction

On September 28, 2018, the combined effect of a 7.5 magnitude earthquake, tsunami and soil liquefaction process caused tremendous damage in the Palu area.

Spatial information and agile assessment methods were crucial to attend affected population.

68,400 dwellings damaged

It is estimated that the combined effect phenomenon of the 28th of September, caused more than 2,100 fatalities, nearly 79,000 displacements and resulted in more than 68,400 dwellings damaged [3].



[3] United Nations Office for the Coordination of Humanitarian Affairs: ReliefWeb. (2018) Situation Update No. 12 M 7.4 Earthquake & Tsunami Sulawesi, Indonesia. <https://reliefweb.int/>

Areas with notable damage before and after the earthquake and tsunami. The Operational Land Imager (OLI) on Landsat 8. The false-color (bands 6-5-2) image shows the same area before and after the earthquake and tsunami. The image shows urban areas in purple-gray, vegetation in green and upturned soil in brown and tan. Image retrieved from [NASA Earth Observatory](https://earthobservatory.nasa.gov/).

What we did

Information was gathered from different sources, and a dataset was developed for Palu. This dataset was included in CPL's Suitability* tool, and an index was developed to identify suitable (or non-suitable) areas for settlement relocation.

The Suitability (ST) tool identifies optimal locations for a specific activity within a city. It does so by evaluating the current status of neighbourhoods across the city, based on the availability of infrastructure, urban equipment and the distance to services and amenities.

25 spatial layers in the dataset

The Suitability* Palu dataset was built with 25 layers, including Built-up area in selected years, Nighttime lights, Altitude, Slope, Proximity to commercial buildings, markets, schools, hospitals, clinics and risk areas.

* For further information about the Suitability tool, please visit: www.suitability.in.

01



Data collection and generation

Palu data was retrieved from ATR, BIG, GHSL, NOAA and AWS, between others.

02



Data standardization

We standardized all datasets to a single coordinate reference system, extent and format.

03



CPL's Suitability tool

The Palu dataset was included in CPL's Suitability tool, to ease further analysis.

04



Analysis

We developed an index to identify suitable (or non-suitable) areas for settlements relocation.

The figure shows the four fundamental steps in the methodology. As described before, the Palu Dataset includes 25 layers, but additionally it includes 17 filters too, which can be used for subsetting areas with a selected land use, a specific type of risk or a type of observed impact.

What we did...

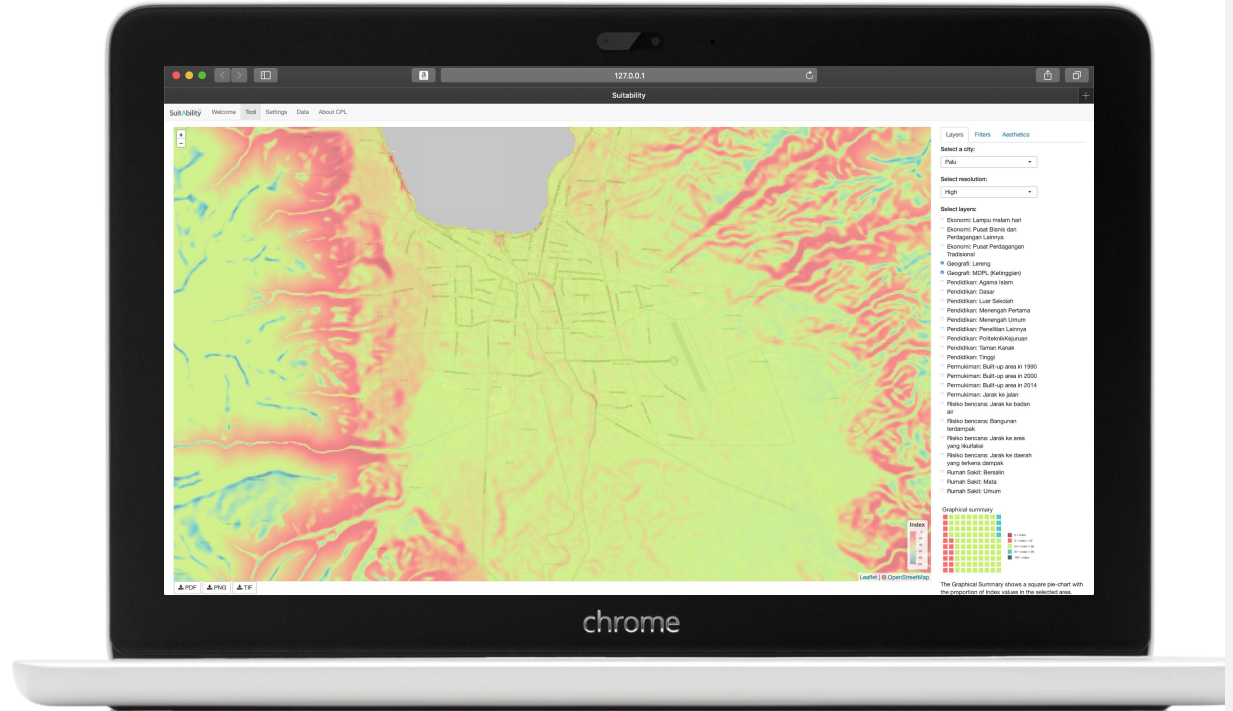
For this case study the ST tool* was used to map areas with a high suitability index for settlement relocation and to identify those areas which are far from optimal for population densification.

Combining layers, normalization rules, and filters we developed 6 maps, which describe areas with a high suitability index for the following categories:

- Disaster prone area - direct impact
- Disaster prone area - on river setbacks
- Agricultural area
- National Park
- Settlement area

The 6 maps were developed to serve as an example. It is important to mention that priority areas were identified for each category. However, it is encouraged for practitioners and decision makers to test other combinations of layers, filters, normalization rules and weights.

* For further information about the Suitability tool, please visit: www.suitability.in.



The figure shows the screenshot of the Suitability tool with the Palu Dataset.

Disaster prone area - direct impact

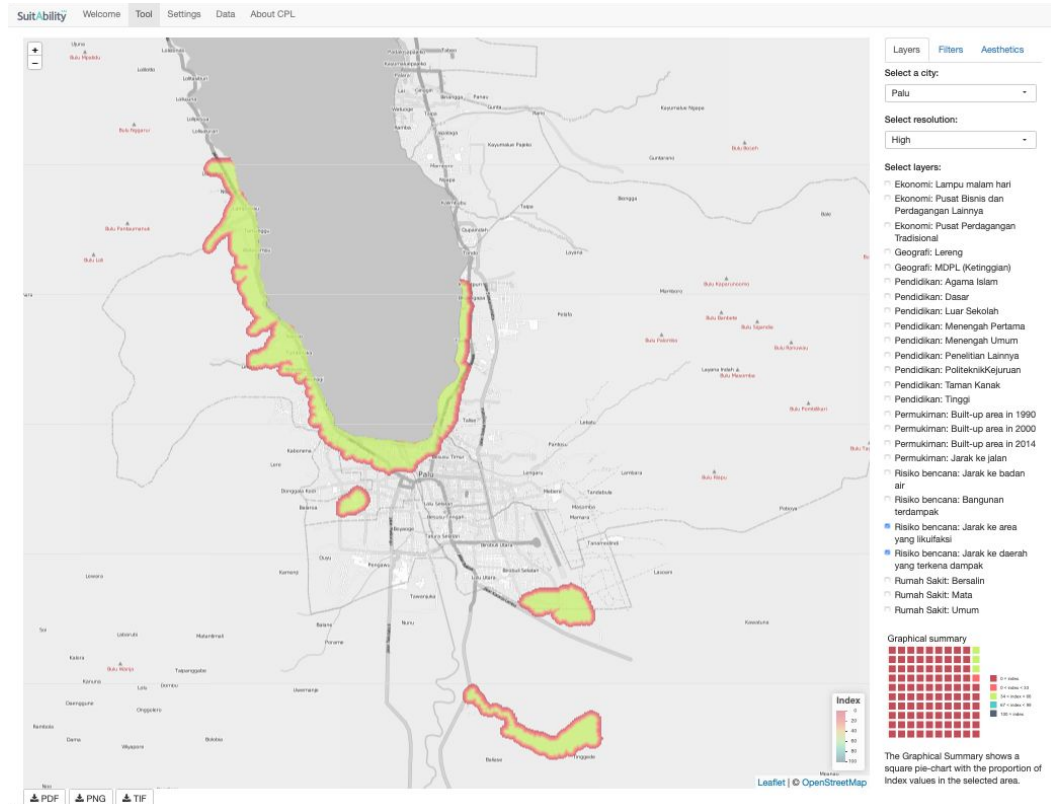
To develop this map all areas with observed direct impacts were considered, either from the tsunami or from liquefaction processes.

The following layers were used for the development of the map:

- 1) Distance to the disaster area: liquefaction
- 2) Distance to the disaster areas: affected zones

A 200 meters buffer for all zones was included.

Areas highlighted in yellow are affected areas and areas in orange-to-red represent the buffer.

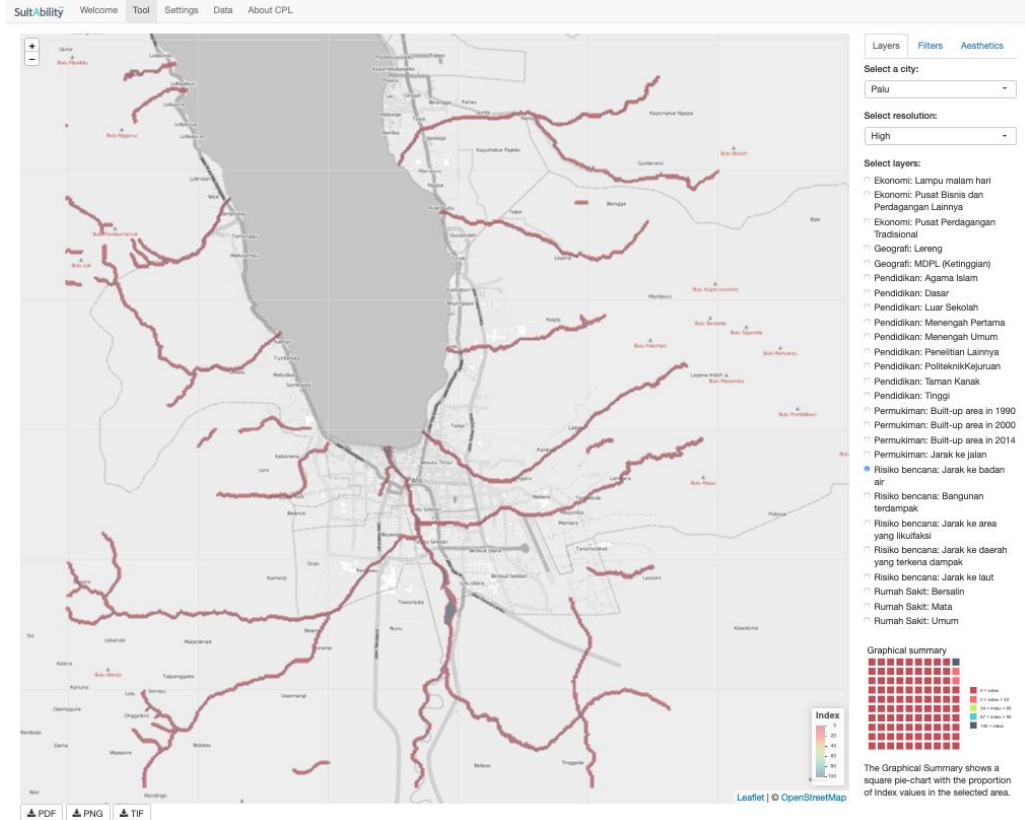


This map was developed by selecting two layers: Distance to the disaster area: liquefaction and distance to the disaster areas: affected zone. To create the buffer we selected a reference normalization method (0 to 200 meters) for both layers.

Disaster prone area - on river setbacks

To develop this map the “Distance to water bodies” layer was used and included a 40 meters buffer for all water bodies was included.

Areas highlighted in blue are water bodies and areas in orange-to-red represent the buffer.



This map was developed by selecting the “Distance to rivers layer”, reference method (0 to 40 meters, “smaller better”) and applied a “subset by score” to keep only those observations with an index higher than 1 point.

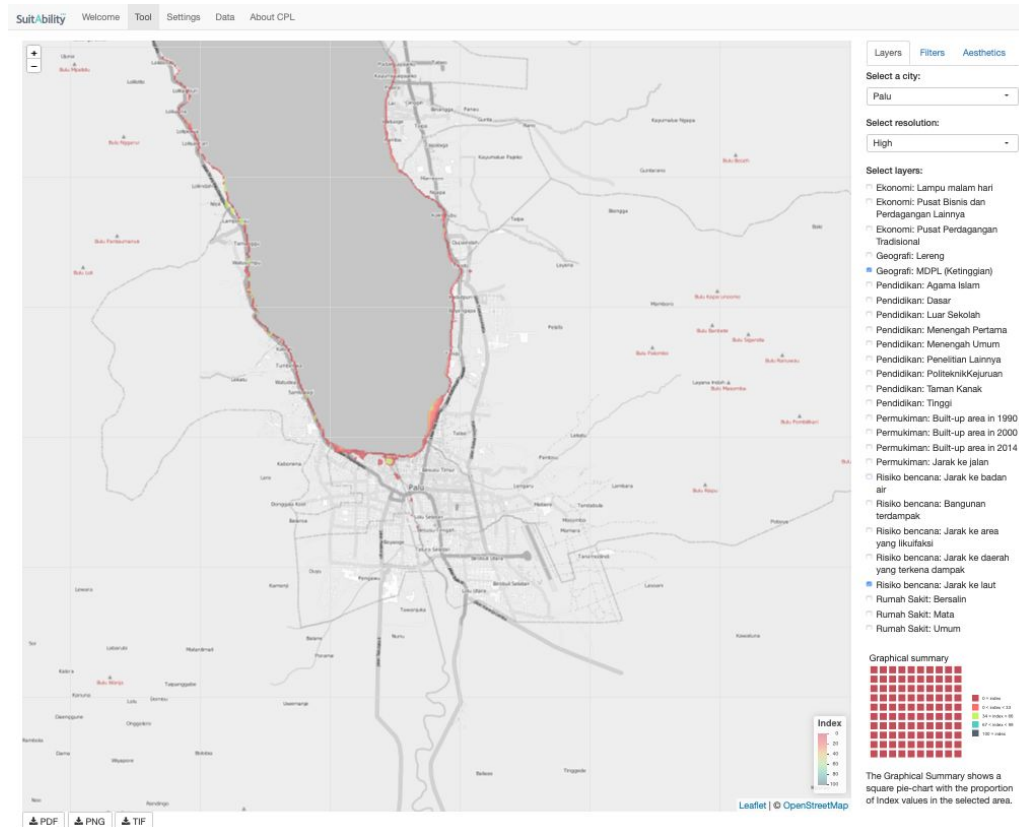
Public park / open space

The “Public park / open space” category is focused on providing public space in the shoreline, while mitigating exposition to risks.

To create this map the following was considered:

- areas with very low altitude (tsunami risk areas, 6 or less m.a.s.l.).
- a setback of 40 meters from the ocean.

Considering both conditions, the altitude layer was used to subset all areas within 6 or less m.a.s.l., and those areas within 40 meters from the shoreline.



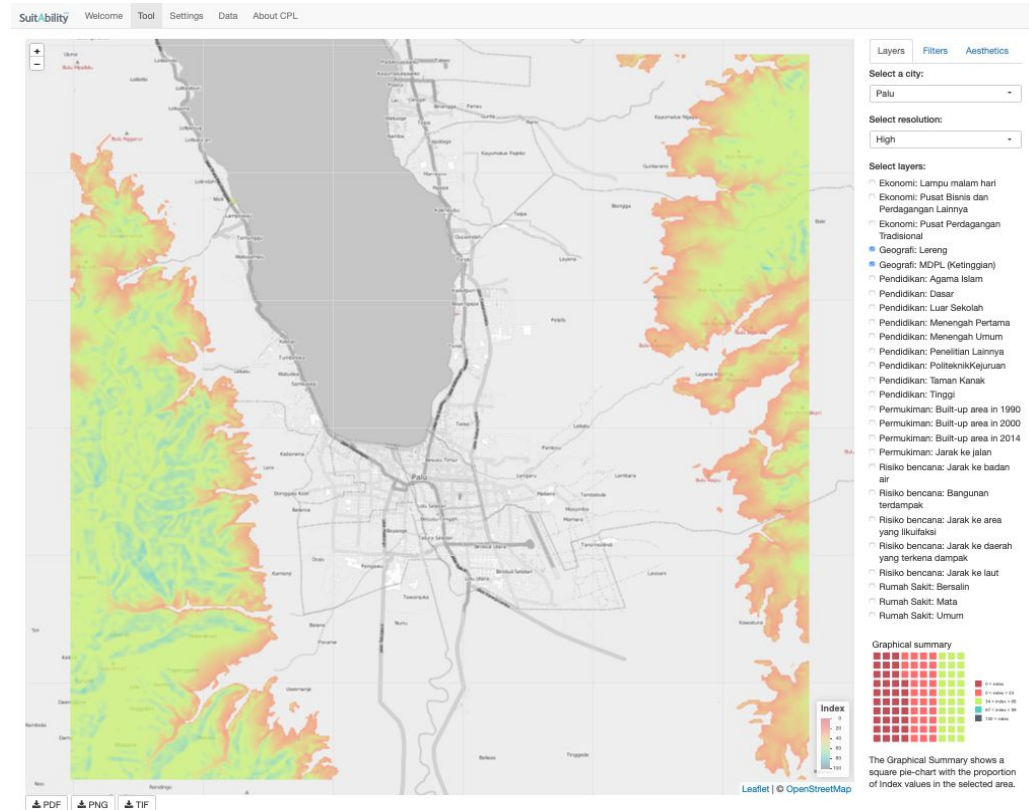
This map was developed by selecting the “Distance to ocean layer”, reference method (0 to 40 meters, “smaller better”); and the altitude layer, reference method (0 to 6 m.a.s.l., “smaller better”). We applied a “subset by score” to keep observations with an index higher than 1 point.

National park

To identify suitable areas in the “National park” category it was considered that:

- a) it is desirable that the existing jungle is conserved, and that
- b) areas with high altitude and slope are environmentally valuable and are exposed to less pressure to land use change.

Considering both conditions, the altitude layer was used to subset all areas within 200 or more m.a.s.l. and slopes of more than 45 degrees.



This map was developed by selecting the “Altitude” layer, reference method (200 to 1000 meters, “larger better”); and the “Slope” layer, reference method (45 degrees and above, “larger better”). We applied a “subset by score” to keep only those observations with an index higher than 60 points.

Settlement area

To identify suitable areas for settlements, it was considered that settlements should be located in areas with low or no-evident risk of natural disasters and low built-up. Additionally, these settlements areas should also have access to existing basic urban services and infrastructure, such as schools, hospitals, roads and employment centers.

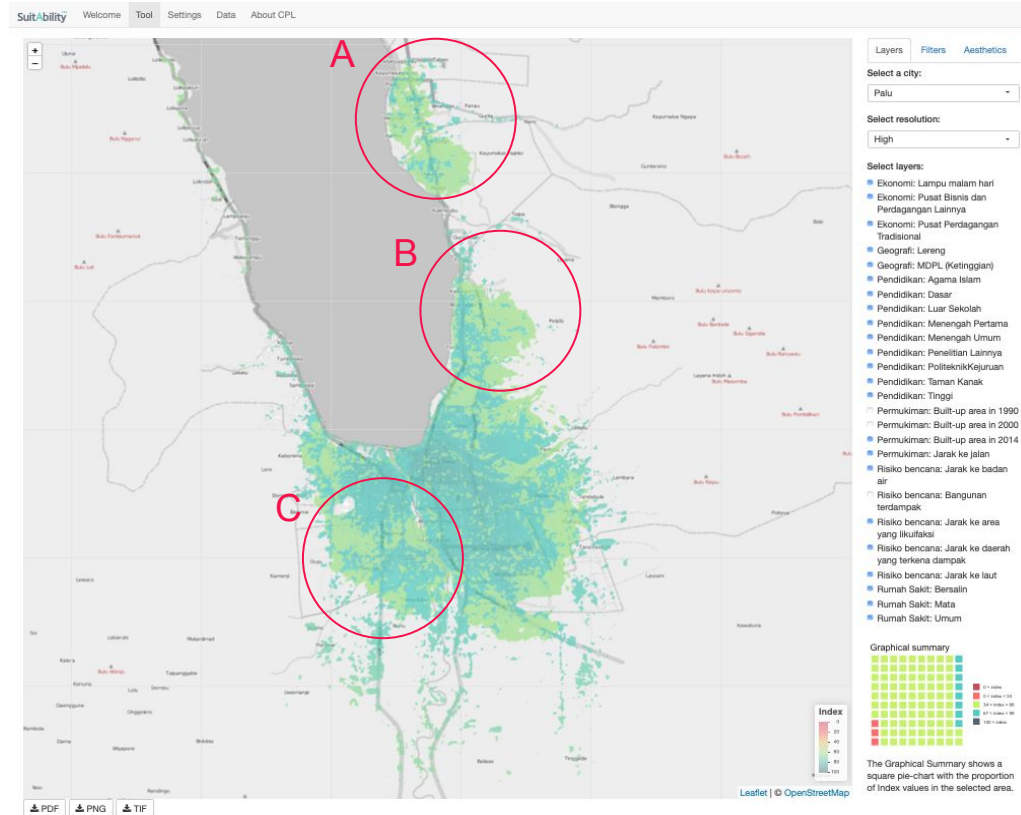
To develop this map 22 layers were included and aggregated in 7 groups:

- 1) Economy
- 2) Geography
- 3) Education
- 4) Population density
- 5) Connectivity
- 6) Risk mitigation
- 7) Health

Each layer was weighted to ensure that groups got equal weights.

Finally, areas with observed liquefaction were filtered out, and a subset of all areas with a suitability index higher or equal to 60 was created. From this analysis 3 areas were recognized 3 with consistent high scores and low-build up.

Please note that the map shows in color blue suitable areas for settlements and in red far from optimal locations.



This map was developed by selecting 22 layers with the observe method, using “smaller better” cases for all urban services and “larger better” for risks and economic activity density. As can be seen from the map, there are 3 notable zones (A, B and C) with consistent high scores and relatively low build-up area (light green color).

Settlement area...

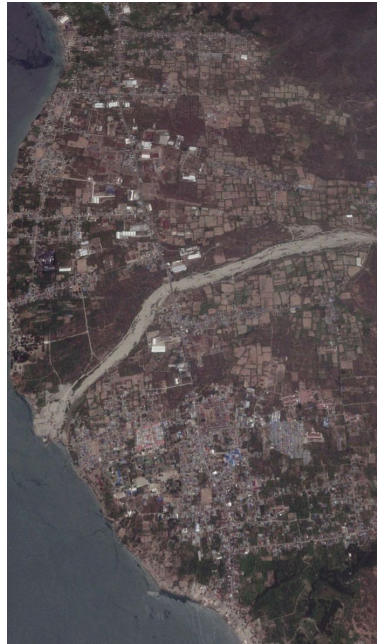
The 3 zones include agricultural land, vacant plots and few settlements.

Zone A includes agricultural land and settlements in Taipa and Mamboro, area.

Zone B includes vacant plots, and settlements surrounding the University of Tadulako.

Zone C includes agricultural land and settlements around Marawola, Sigi area.

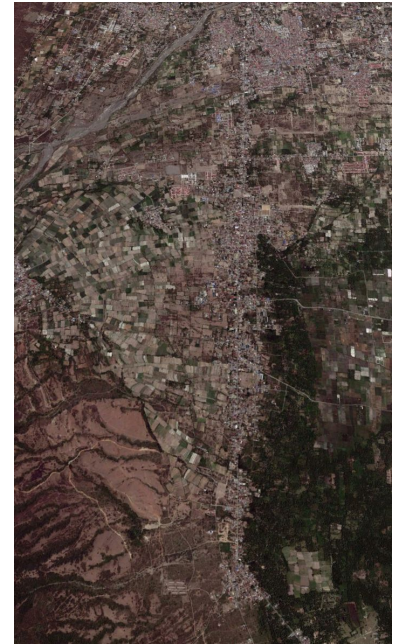
A



B



C



Zone A includes agricultural land and settlements in Taipa and Mamboro, area. Zone B includes vacant plots, and settlements surrounding the University of Tadulako. Zone C includes agricultural land and settlements around Marawola, Sigi area.

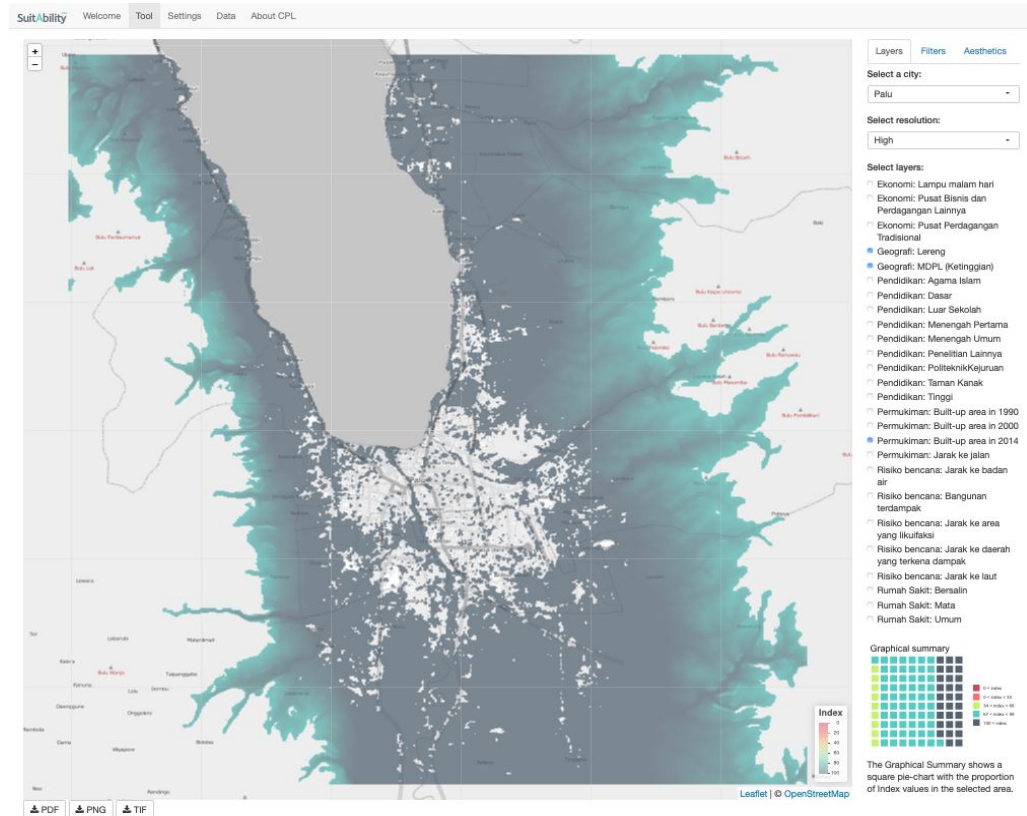
Agricultural area

Suitable areas were considered to have lower slope (0 to 45 degrees), relative low altitude and non or very-low built-up area.

To identify suitable areas for agriculture the following layers were used:

- 1) Slope
- 2) Distance to water bodies
- 3) Built-up area

Areas in blue are have the highest suitability index for agriculture. It is important to note that there is an apparent competition between settlements and agricultural areas. We will describe more about this in the next pages.



This map was developed by selecting the “Altitude” layer, with the reference method (200 to 1000 meters, “smaller better”); the “Slope” layer, with the reference method (45 degrees and above, “smaller better”) and the Built-up area layer with the observe method. Finally a “subset by score” was applied to keep only those observations with an index higher than 80 points.

Integrated map

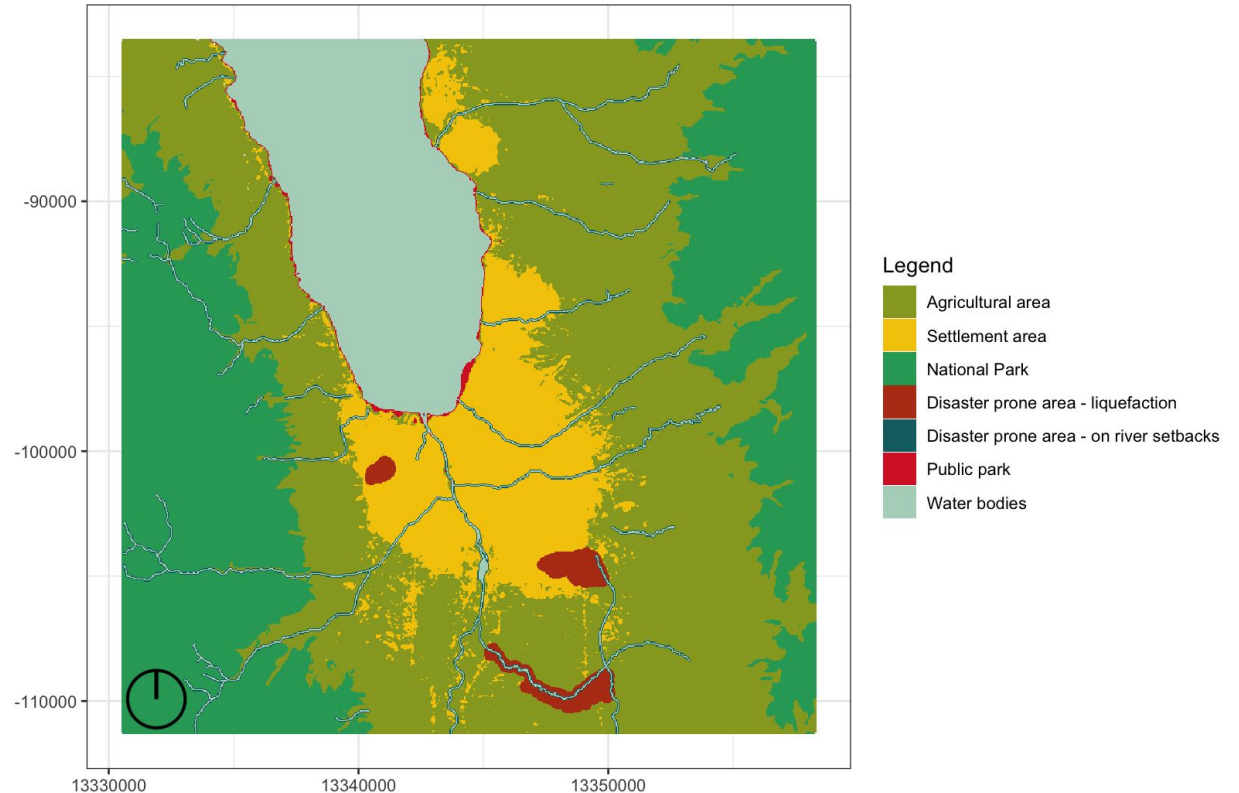
Finally, the results from the previous 6 analysis were integrated in a single map.

For this case study, the thematic maps were developed with the Suitability* tool and integrated with R Statistical Software Environment, version 3.4.4 [4].

Further details on integration of the map can be revised in the digital annex of this document.

This is a final important note. The 6 maps were developed to serve as an example where priority-areas were identified for each land use category. This case study should serve as an example of how the Suitability tool and its methods can be used for spatial planning.

Practitioners and decision makers are encouraged to test other combinations of layers, filters, normalization rules and weights to identify their own optimal locations.



* For further information about the Suitability tool, please visit:

www.suitability.in.

[4] R Core Team (2014). [R: A language and environment for statistical computing](https://www.r-project.org/). R Foundation for Statistical Computing, Vienna, Austria.

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