Inverse Distance Weighting Interpolated Soil Properties and Their Related Landslide Occurrences

Purwanto Bekti Santoso

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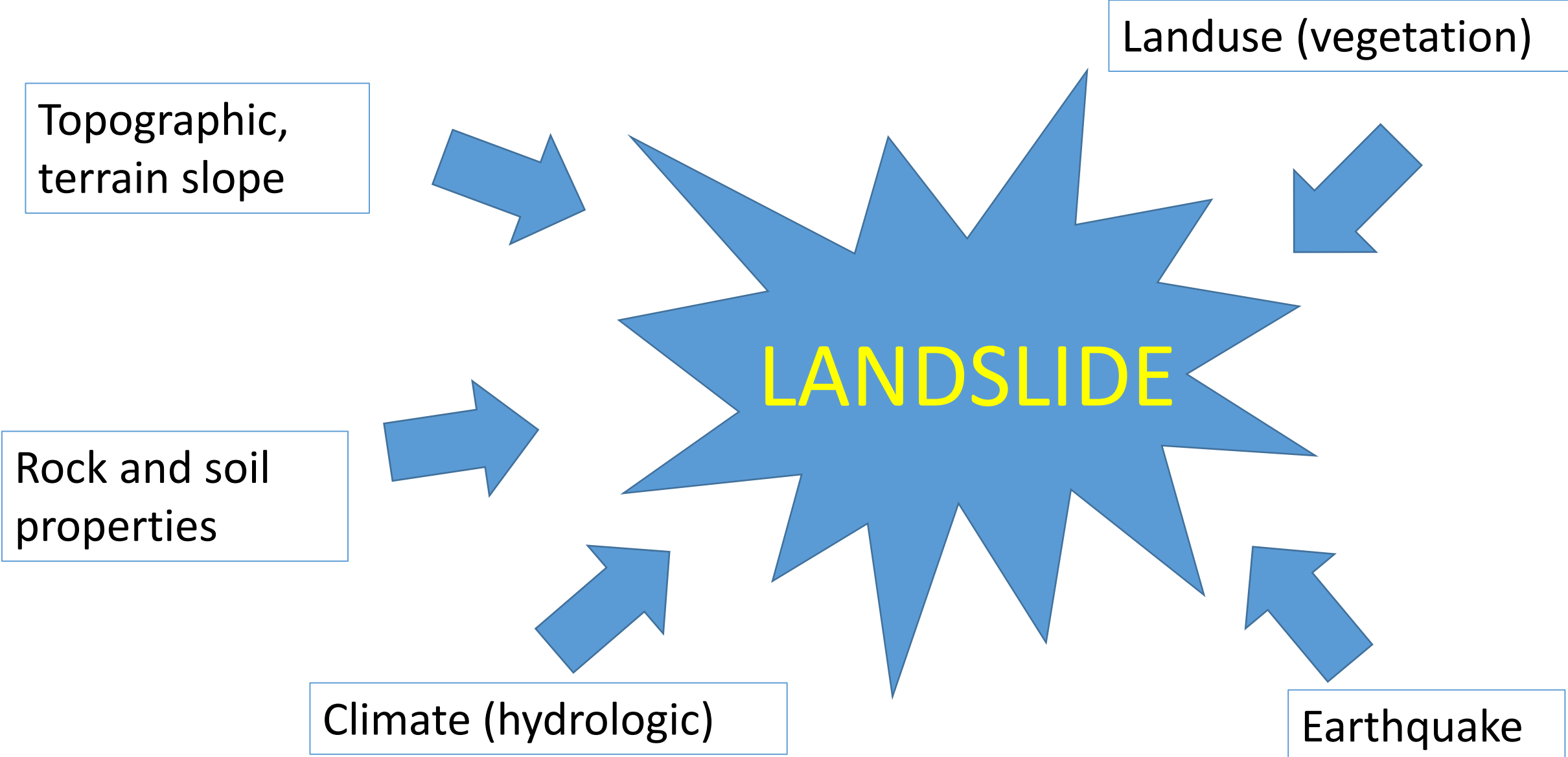
Arwan Apriyono

Rani Suryani

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY OF JENDERAL SOEDIRMAN

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Background

Topographic, terrain slope

Landuse (vegetation)

Rock and soil properties

LANDSLIDE

Climate (hydrologic)

Earthquake

Background

- Works on identifying approximate regions of potential landslide risk were mostly based on topographic and hydrologic condition, i.e. by overlaying parameters of topography, geology, land use, and climate. Each of which was scored to represent its effect on landslide.

- Landslide is caused by instability of slope, therefore identification approximate regions of potential landslide risk should be based on slope stability factor.

- Slope stability requires calculations of the driving forces (gravitational forces due to weight of soil and water, and other overburden loads) and the **resistive forces (soil shear strength)**.

- Soil shear strength depends on **soil properties**.

- Soil properties data are not always available at locations of interest.

- A method of interpolation is necessary to approximate soil properties at location of interest.

Purpose

- Interpolate scattered soil properties data using Inverse Distance Weighting (IDW) method to get evenly spatial distribution of soil properties.

- Relate interpolated soil properties with landslide occurrences.

Location of Study

Western part of Central Java:
Wonosobo, Temanggung, Kebumen, Banjarnegara, Purbalingga, Banyumas, Cilacap, Brebes, Tegal, Pekalongan and Pemalang

Frame of study
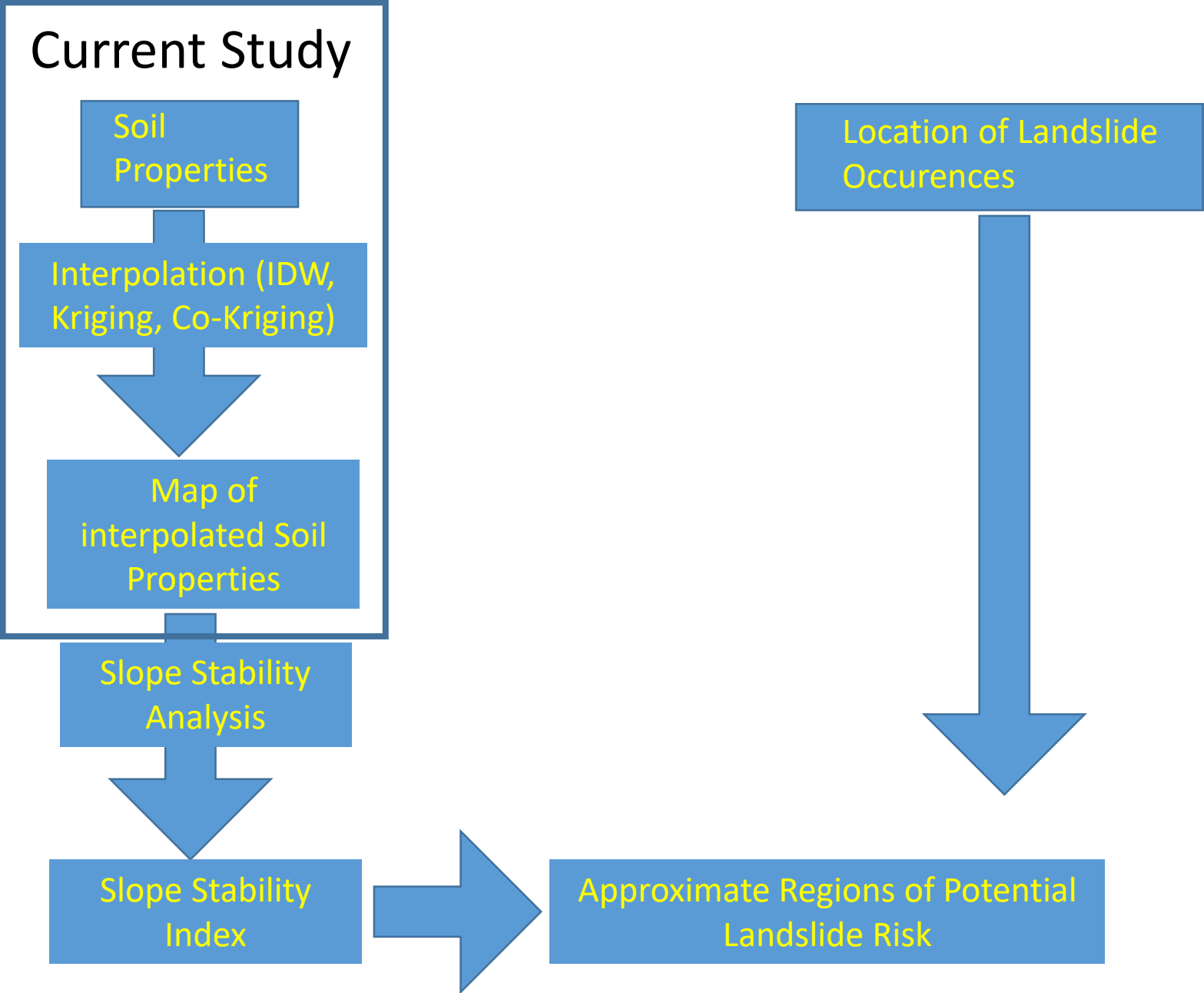
Inverse Distance Weighting (IDW) Method

The IDW formulation is

$$\hat{q} = \frac{\sum_{i=1}^{n} \frac{1}{r_i^\alpha} q_i}{\sum_{i=1}^{n} \frac{1}{r_i^\alpha}}$$

Where:

$\hat{q}$: interpolation target value

q_i : known value at location i

r_i : distance between the target and the known value at location i

α : weighting factor

n : number of known data considered in the interpolation

Data and parameter for the interpolation

- Data were collected from 336 sites over the years of 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2014, 2015 and 2016.

- Depths of hardrock : 336 data

- Soil cohesion : 226 data

- Internal friction angle : 228 data

- the distance between the target and the known value was calculated based on location coordinates

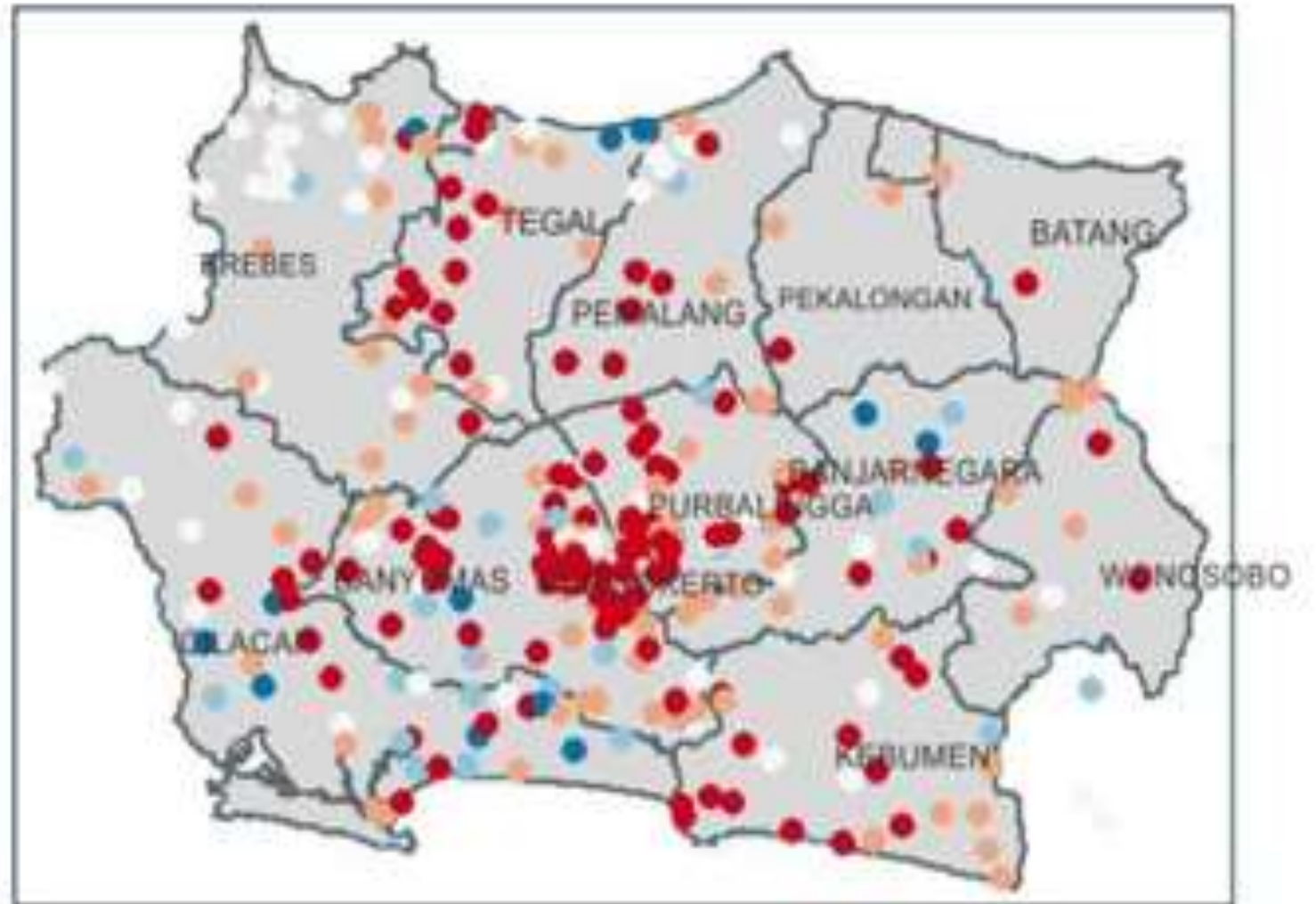- the weighting factors used in the interpolation were α= 1,2,3.

Validation

- validation of the interpolation makes use of the percent bias

$$\frac{q_{ukur} - q_{inter}}{q_{ukur}} \; x \; 100\%$$

- q_{ukur} and q_{inter} represent measured and interpolated value.
- The data were randomly splitted so that 15% data was the target of validation, and 85% data was interpolated.
- There were 10 interpolation trials per weighting factor, each of which was evaluated according to its percent bias.

Spatial distribution of Depths of hardrock

Depth of hardrock or bedrock (m)

- 0 to 5
- 5 to 10
- 10 to 15
- 15 to 20
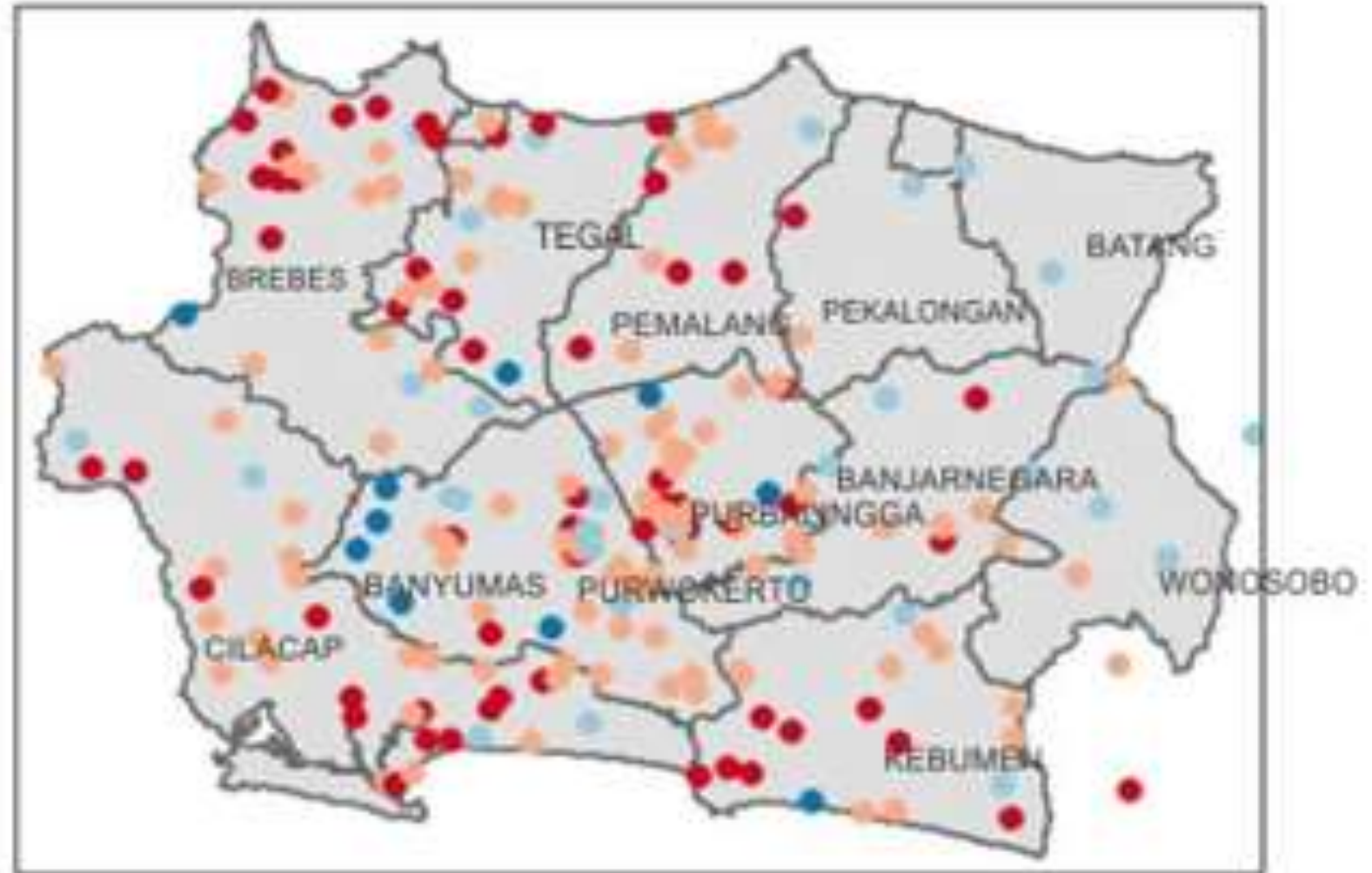- 20 to 25

Spatial distribution of Soil Cohesions

Soil cohesion (kg/m²)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0

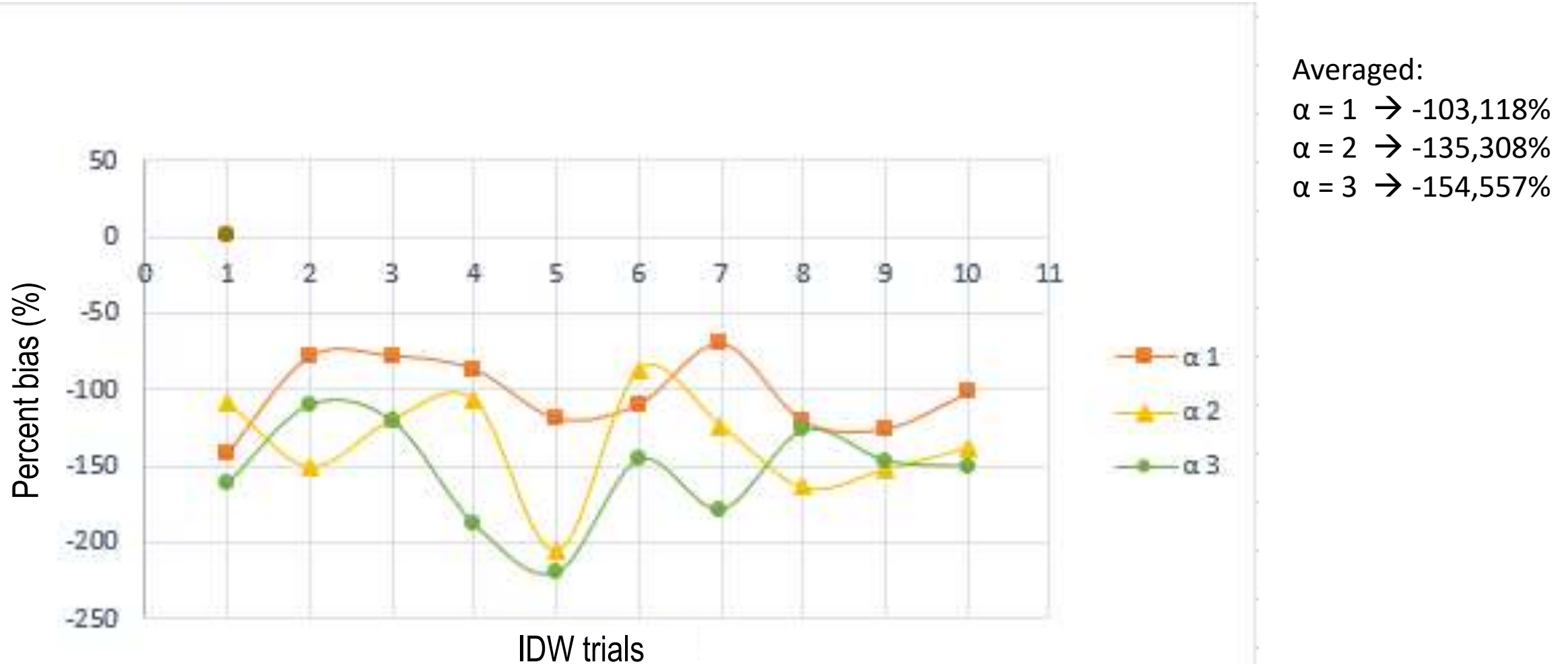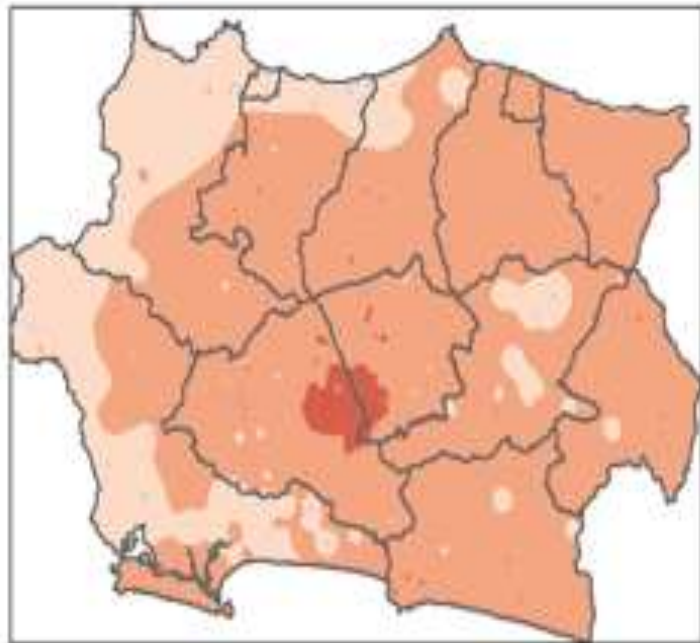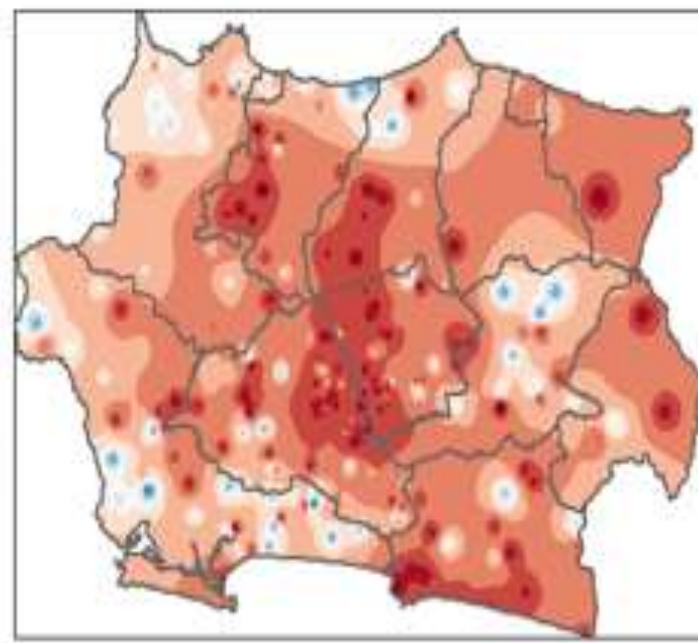# Spatial distribution of internal friction angle

Internal friction angle (^{0})

- ● 0 to 20
- ● 20 to 40
- ● 40 to 60
- ● 60 to 80

Weighting factor effect on percent bias (depths of hardrock interpolation)

Averaged:
α = 1 → -103,118%
α = 2 → -135,308%
α = 3 → -154,557%

Map of interpolated depths of hardrock

α = 1   α = 2   α = 3

0 to 2
2 to 4
4 to 6
6 to 8
8 to 10
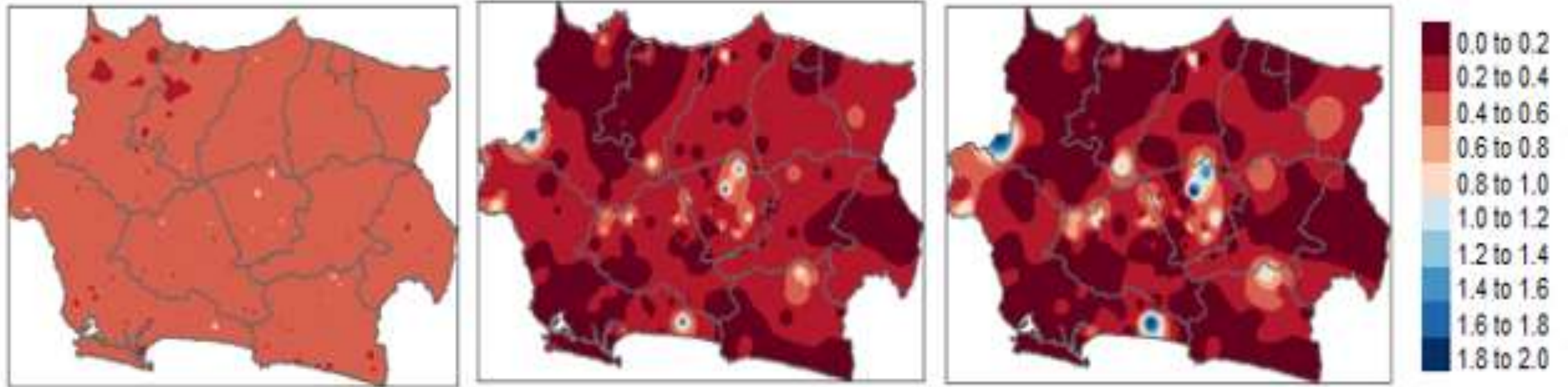10 to 12
12 to 14
14 to 16
16 to 18
18 to 20
20 to 22
22 to 24
24 to 26
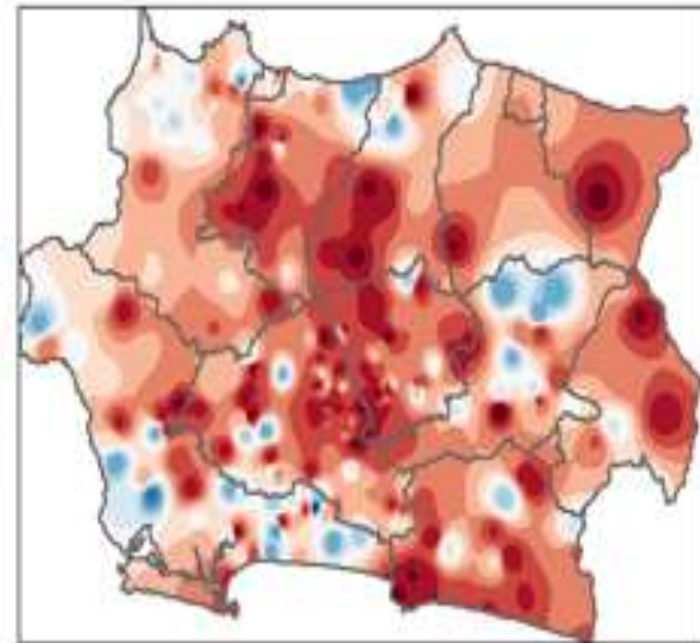
Weighting factor effect on percent bias (soil cohesion interpolation)
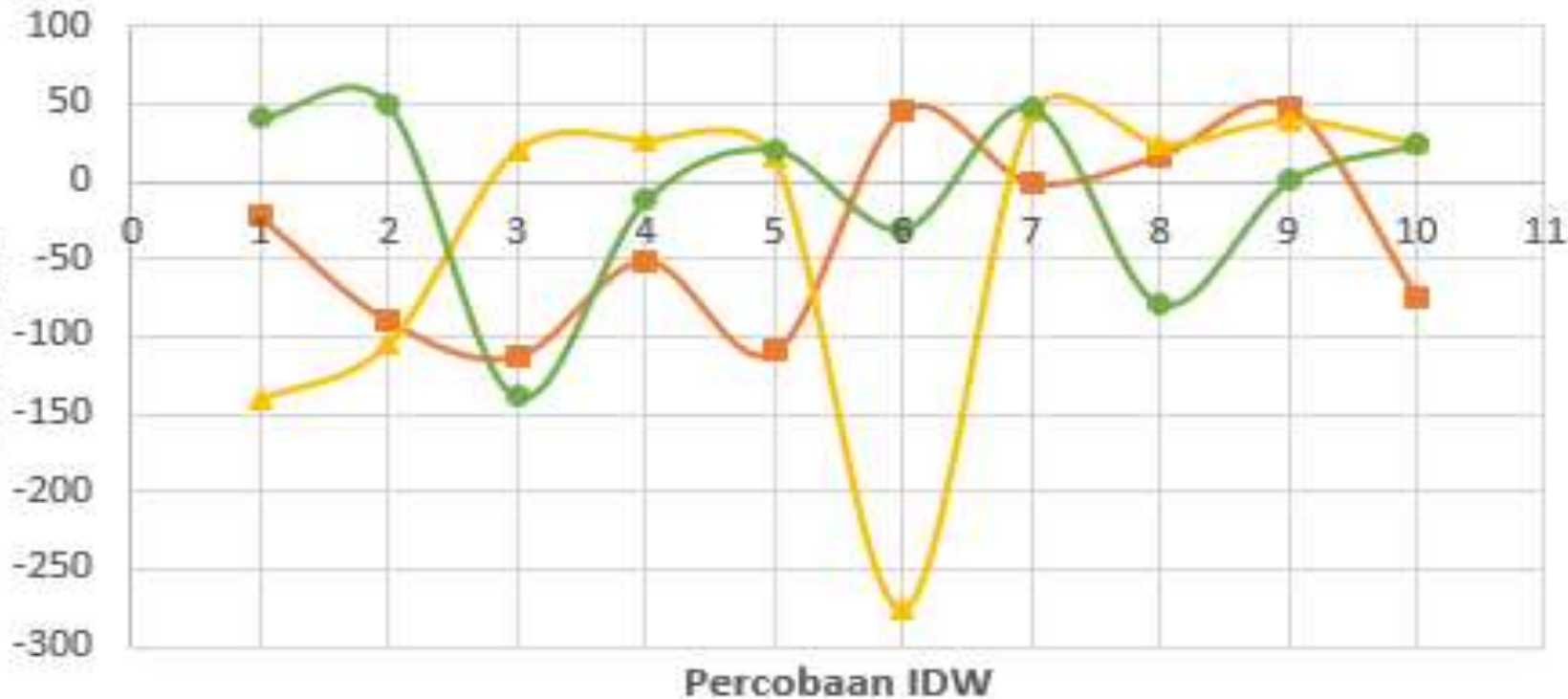
Map of interpolated soil cohesion data

α = 1   α = 2   α = 3

0.0 to 0.2
0.2 to 0.4
0.4 to 0.6
0.6 to 0.8
0.8 to 1.0
1.0 to 1.2
1.2 to 1.4
1.4 to 1.6
1.6 to 1.8
1.8 to 2.0

Weighting factor effect on percent bias (interpolation of internal friction angle)

Averaged:
α = 1 → -34,844%
α = 2 → -32,556%
α = 3 → -7,488%

Map of interpolated internal friction angle data

α = 1 α = 2 α = 3
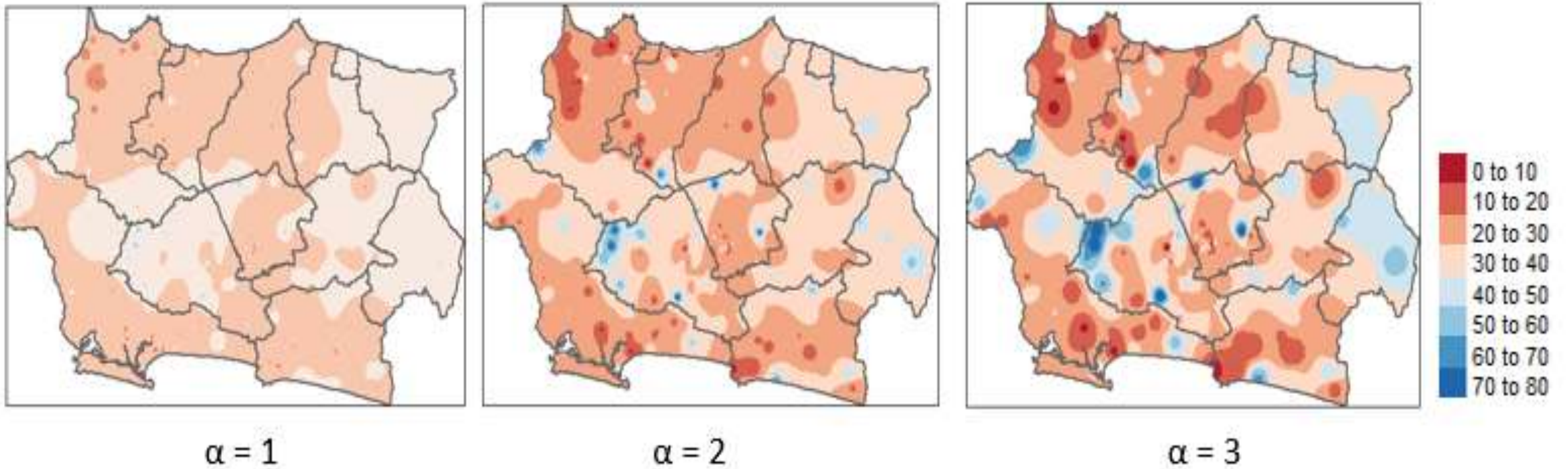
Interpolated Hardrock Depths and Their Related Landslide Occurences

α = 1   α = 2   α = 3
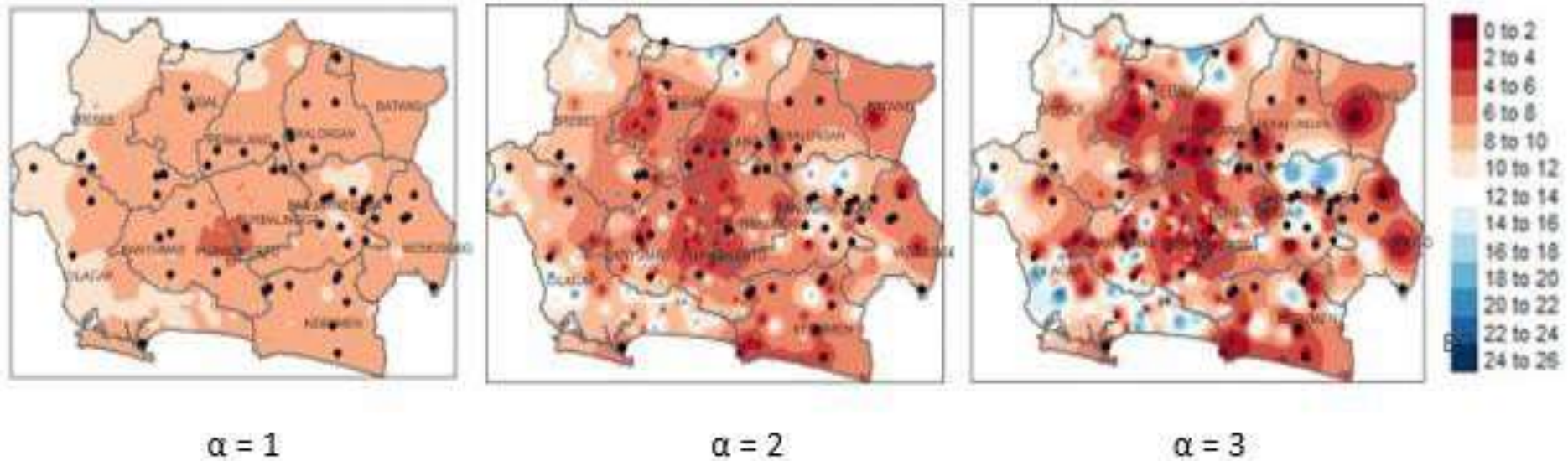
Weighting factor	Hardrock depth (m)					
	$2 - 4$	$4 - 6$	$6 - 8$	$8 - 10$	$10 - 12$	$12 - 14$
α = 1	-	1	52	10	1	-
α = 2	1	12	29	18	2	2
α = 3	8	12	21	15	1	7

Interpolated Soil Cohesions and Their Related Landslide Occurences

α = 1   α = 2   α = 3
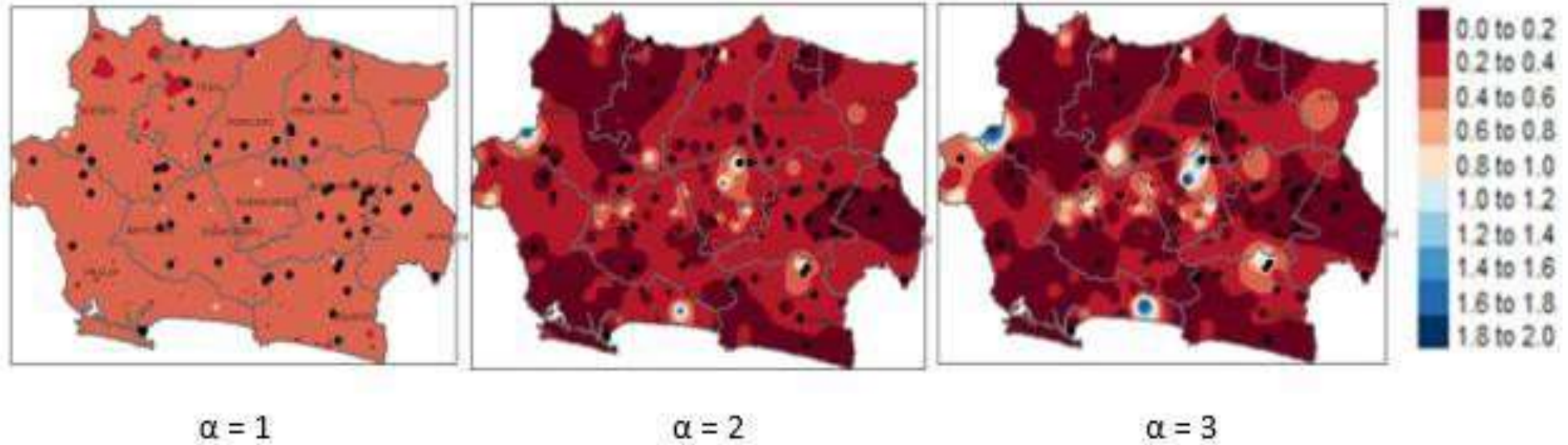
Weighting factor	soil cohesion (kg/cm²)					
	$0.0 - 0.2$	$0.2 - 0.4$	$0.4 - 0.6$	$0.6 - 0.8$	0.8 - 1	1- 1.2
α = 1	2	61	-	1	-	-
α = 2	28	32	-	2	2	-
α = 3	36	22	3	2	-	1

Interpolated Internal Friction Angle and Their Related Landslide Occurences

α = 1   α = 2   α = 3
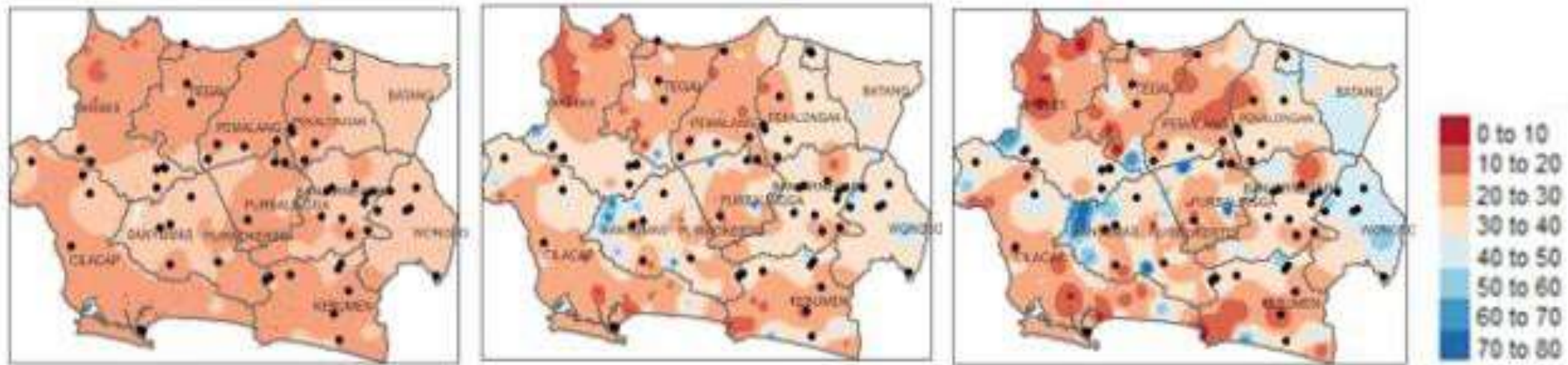
Weighting factor	internal friction angle (^{0})					
	10 – 20	20 – 30	30 – 40	40 – 50	10 – 20	20 – 30
α = 1	-	29	35	-	-	29
α = 2	1	18	43	2	1	18
α = 3	1	16	37	10	1	16

CONCLUSION

- Concerning the percent bias, The validities of resulted spatial distributions were varies according to selection of weighting factor.

- IDW interpolation using higher weighting factor corresponds with higher percent bias in case of depth of hardrock and soil cohesion, while oppositely found in case of the internal friction angle .

- Validation to landslide incident in western part of Central Java Province shows that the majority of landslide incident occurs at depths of hardrock of 6 m - 8 m, at soil cohesion of 0.0 kg/cm^2 – 0.2 kg/cm^2, and at internal friction angle of 30^0 - 40^0.