Integrating Soil Health Indicators and Remote Sensing for Sustainable Soil Health Assessment: A Case Study of the Huai Krasiew Sub-watershed

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Introduction

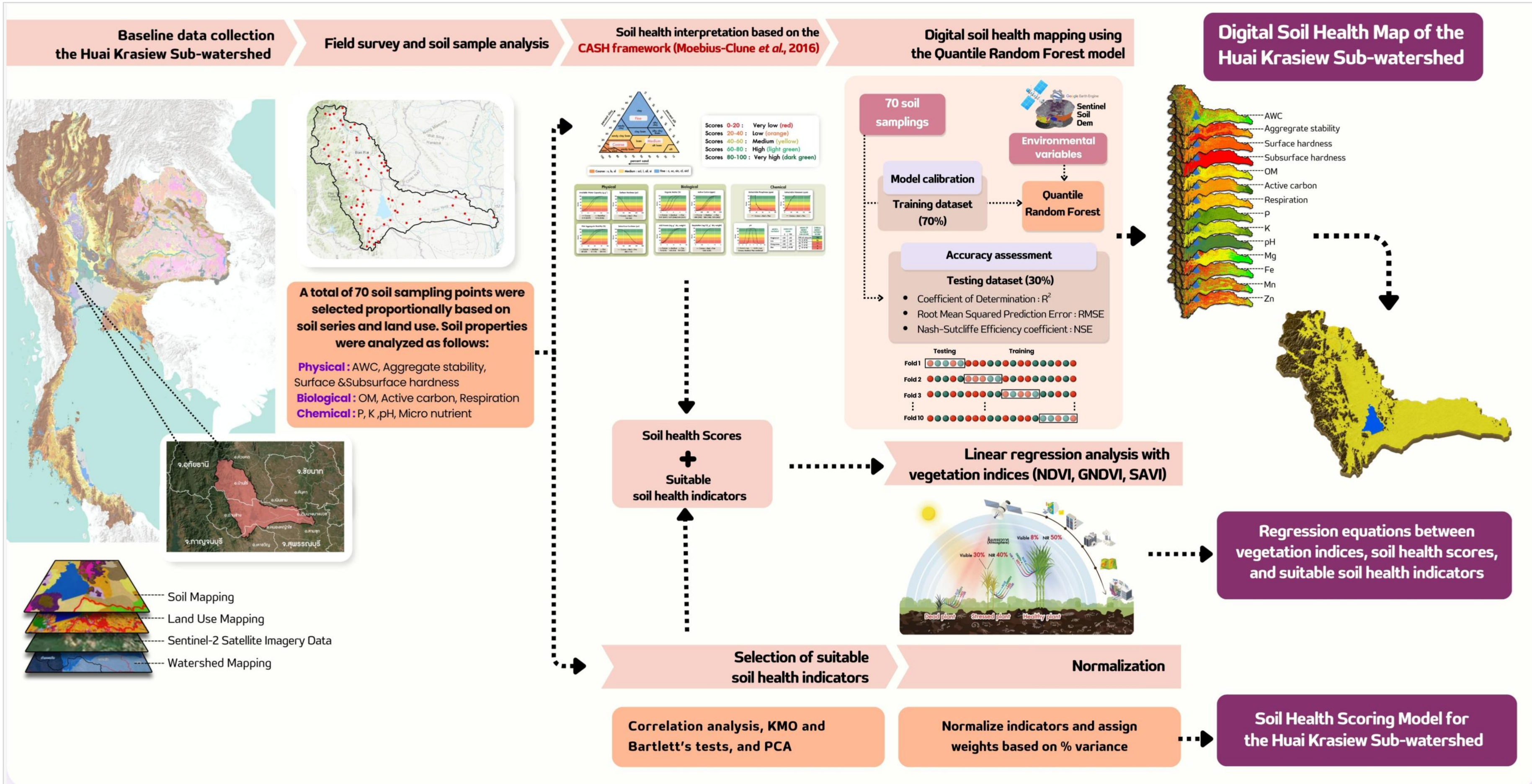
Soil health indicators are important because they reflect the capacity of soils to support plant growth, maintain soil fertility, preserve ecosystem balance, and contribute to sustainable land management. Healthy soils are characterized by good water retention and balanced soil properties, which play a crucial role in reducing soil degradation and supporting sustainable watershed management. However, conventional soil health assessment over large areas remains constrained by limitations in time, labor, and resources. Therefore, remote sensing techniques have increasingly been applied to improve assessment efficiency and spatial coverage, while enabling the identification of degraded soils and low soil health areas that may be vulnerable to environmental risks and disasters.

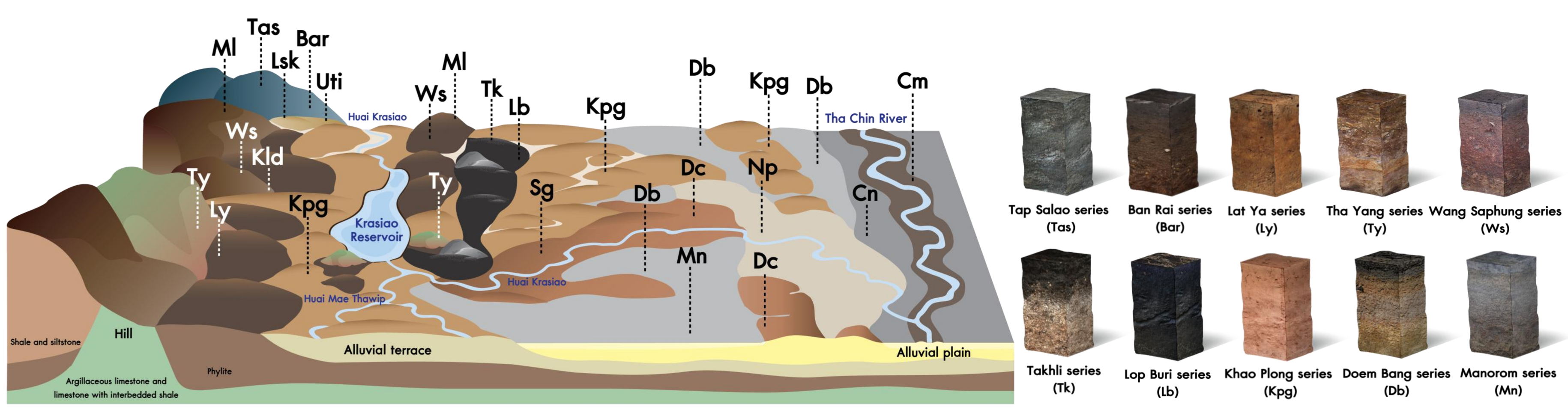
The Cornell Framework was applied to assess soil health in the Huai Krasiew Sub-watershed through the analysis of relationships among soil health indicators using the Pearson Correlation Coefficient and Principal Component Analysis (PCA) to determine the most suitable indicators. In addition, the potential of remote sensing–based vegetation indices, including NDVI, GNDVI, and SAVI, was evaluated for assessing degraded soils and areas with low soil health.

Objectives

1. To investigate the physical, chemical, and biological soil properties affecting soil health in the Huai Krasiew Sub-watershed.
2. To identify suitable soil health indicators and assess soil health in the Huai Krasiew Sub-watershed.
3. To evaluate the potential of remote sensing data for assessing soil health in sugarcane-growing areas of the Huai Krasiew Sub-watershed.

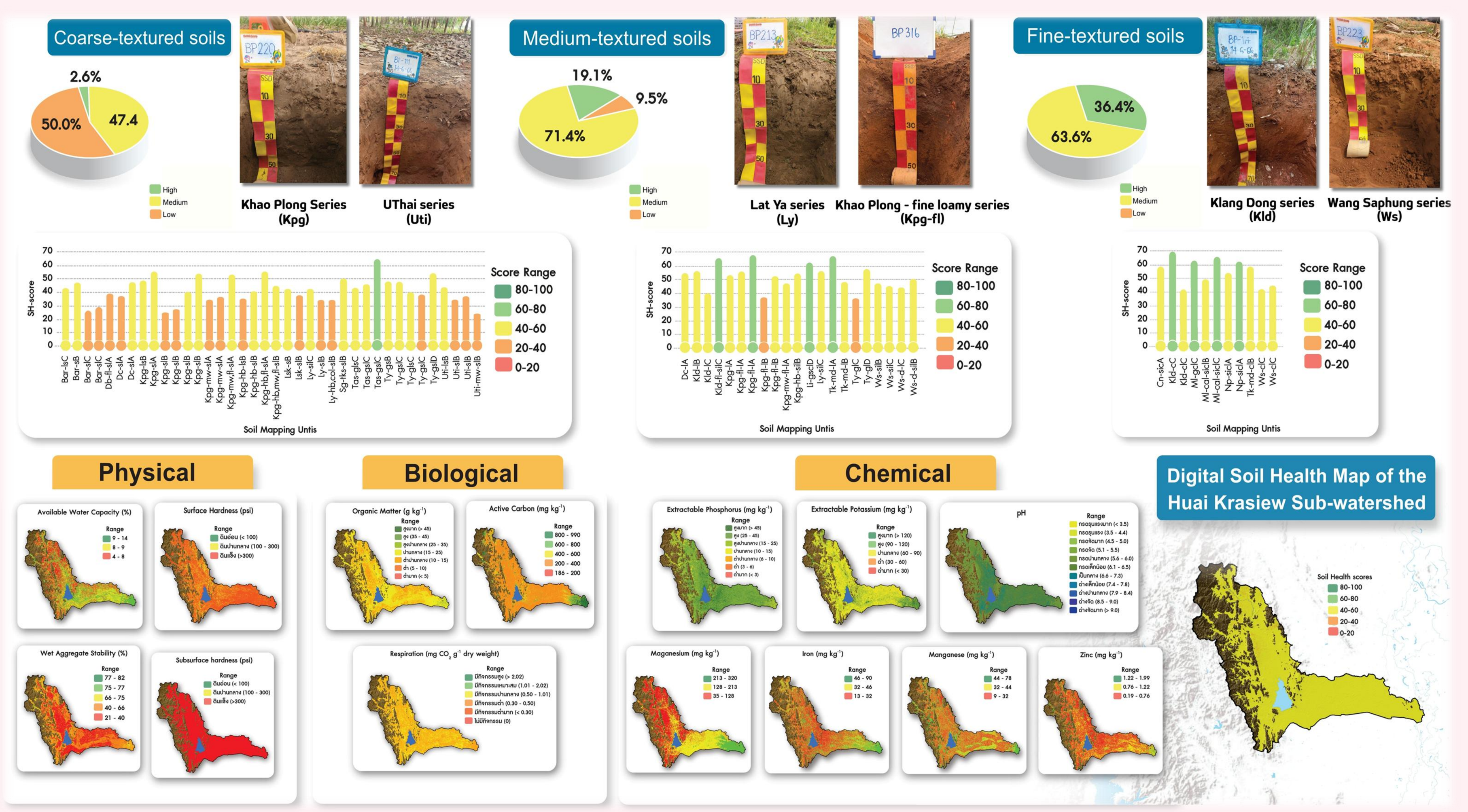
Methodology





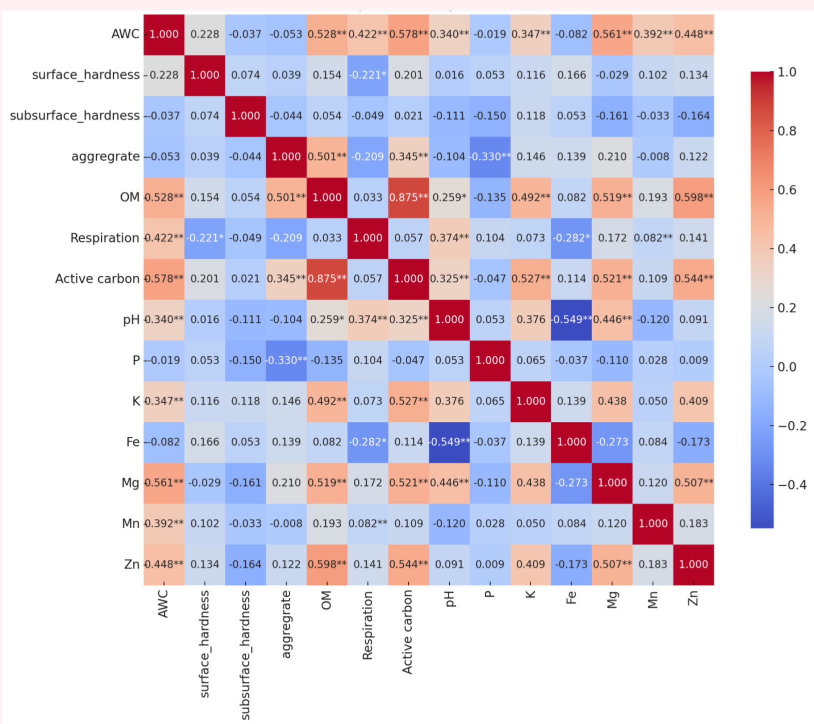
Results

1. Soil Health in the Huai Krasiew Sub-watershed



2. Suitable Soil Health Indicators for the Huai Krasiew Sub-watershed

2.1 Pearson Correlations between Soil Health Indicators



Pearson correlation coefficients

Active Carbon - AWC	0.578**	OM - Active Carbon	0.875**
Active Carbon - K	0.527**	OM - Aggregate	0.501**
Active Carbon - Mg	0.521**	OM - AWC	0.528**
Active Carbon - pH	0.325**	OM - K	0.492**
Active Carbon - Zn	0.544**	OM - Mg	0.519**
AWC - K	0.347**	OM - Zn	0.598**
AWC - Mg	0.561**	pH - Fe	-0.549**
AWC - Zn	0.448**	pH - Respiration	0.374**

Variables of Significance (*p ≤ 0.05, **p ≤ 0.01)

2.2 Principal Component Analysis of Soil Health Indicators

KMO & Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		0.737
Bartlett's Test of Sphericity	Chi-Square	422.890
	df	91
	Sig.	0.000

	PCA1	PCA2	PCA3	PCA4	PCA5
Eigenvalue	4.058	2.110	1.542	1.188	1.142
% Variance	28.984	15.072	11.017	8.485	8.158
OM	0.906				
Active carbon	0.905				
K	0.664				
Mg	0.643				
Zn	0.579				
Fe		-0.793			
pH		0.769			
Respiration		0.640			
Mn			0.837		
AWC	0.532		0.608		
P				0.898	
Aggregate stability	0.507			-0.546	
Subsurface hardness					0.837
Surface hardness					0.510

PCA1
- Aggregate stability
- AWC
- K
- OM

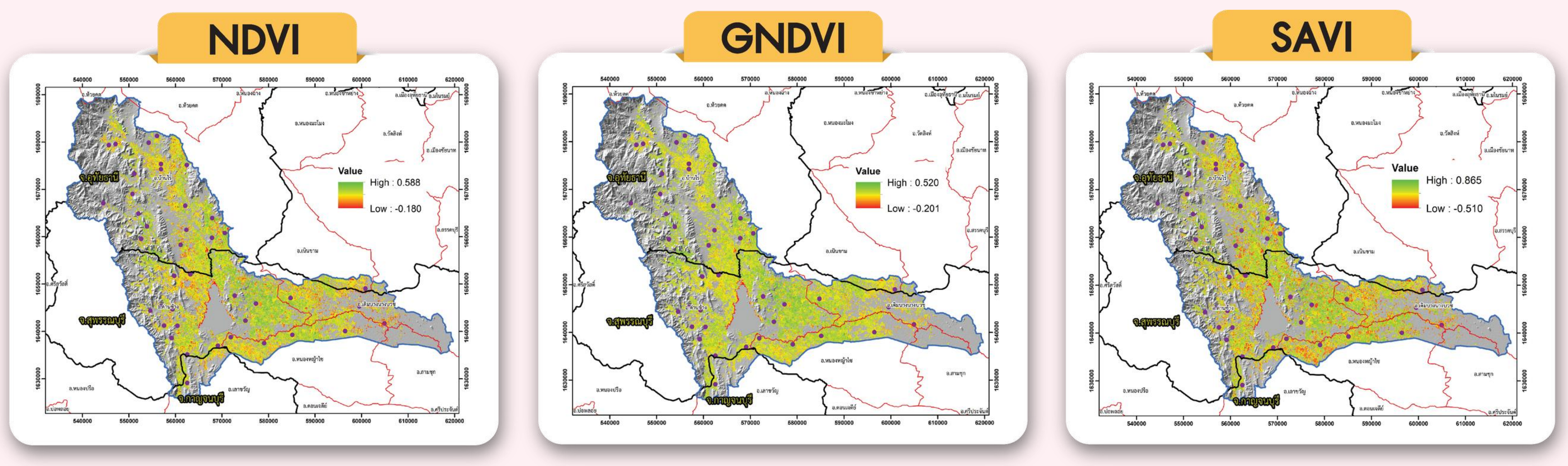
PCA2
- pH
- Respiration

Soil Health Scoring Model for the Huai Krasiew Sub-watershed

SSpeSHS = (0.0725·Aggregate) + (0.0725·AWC) + (0.0725·K) + (0.0754·pH) + (0.0725·OM) + (0.0754·Respiration)

SspeSHS = Site-Specific Soil Health Score

3. Relationships of Soil Health Scores and Suitable Indicators with Remote Sensing Data



Suitable Indicators	Vegetation indices	Linear regression analysis	R^2	p-value
SH-Score	NDVI	SH =14.096+118.302(NDVI)	0.567**	<0.001
	GNDVI	SH =5.236+168.397(GNDVI)	0.450**	<0.001
	SAVI	SH =22.540+47.713(SAVI)	0.520**	<0.001
Aggregate	NDVI	Aggregate =56.735−42.861(NDVI)	0.019	0.390
	GNDVI	Aggregate =59.692−59.943(GNDVI)	0.014	0.453
	SAVI	Aggregate =40.263+11.025(SAVI)	0.007	0.601
AWC	NDVI	AWC =3.075+20.225(NDVI)	0.197**	0.003
	GNDVI	AWC =0.725+32.314(GNDVI)	0.197**	0.003
	SAVI	AWC =5.866+5.313(SAVI)	0.077	0.076
Potassium	NDVI	K = 18.499+17.466(NDVI)	0.001	0.850
	GNDVI	K = 39.012−67.211(GNDVI)	0.005	0.649
	SAVI	K =20.270+5.938(SAVI)	0.001	0.879

Suitable Indicators	Vegetation indices	Linear regression analysis	R^2	p-value
pH	NDVI	pH=3.824+10.032(NDVI)	0.336**	<0.001
	GNDVI	pH=3.439+12.735(GNDVI)	0.212**	0.002
	SAVI	pH=4.631+3.855(SAVI)	0.280**	<0.001
OM	NDVI	OM =−0.430+6.666(NDVI)	0.259**	0.001
	GNDVI	OM =−1.429+11.594(GNDVI)	0.306**	<0.001
	SAVI	OM =0.128+2.515(SAVI)	0.208**	0.002
Respiration	NDVI	Respiration =0.232+1.057(NDVI)	0.082	0.066
	GNDVI	Respiration =0.212+1.256(GNDVI)	0.045	0.176
	SAVI	Respiration =0.278+0.489(SAVI)	0.099*	0.042

Conclusion

The most suitable indicators for assessing soil health were aggregate stability, available water capacity, extractable potassium, soil pH, organic matter, and respiration. Remote sensing analysis revealed that NDVI explained a greater proportion of variation in soil health scores than the other vegetation indices (R^2 = 0.567), and also showed moderate relationships with soil pH (R^2 = 0.336) and Organic Matter (R^2 = 0.259). Based on the soil health assessment, 57.1% of the study area was classified as having medium soil health, followed by low soil health (30.0%) and high soil health (12.9%).

These findings demonstrate that integrating selected soil health indicators with remote sensing techniques can support the identification of degraded soils and areas with low soil health, thereby contributing to sustainable land management, spatial risk mapping, and disaster risk reduction planning.

References / Footnotes

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