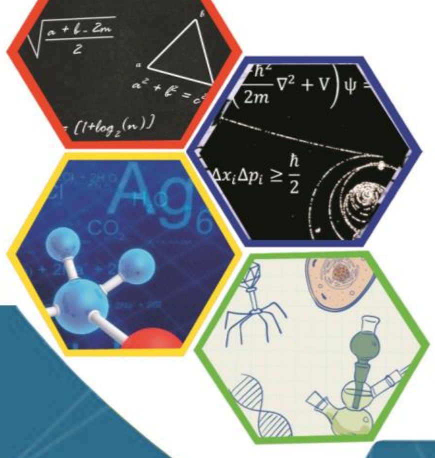
PROCEEDING

The 2nd International Seminar of Basic Science

Natural Science For Exploration The Sea-Island Resources

Ambon, May 31st 2016



Organized by

Faculty of Mathematics and Natural Science
Pattimura University

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The 2nd International Seminar of Basic Science

"Natural Science for Exploration The Sea-Island Resources"

Poka-Ambon, 31st May 2016

Mathematic and Natural Science Faculty
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2nd edition

Welcoming Address By The Organizing Committee

Today, We have to thank the The Almighty Allah SWT for the implementation of this international seminar. This is the second seminar about Basic Science in The Faculty of MIPA Pattimura University. The seminar under the title "Natural Sciences for Exploration the Sea-Island Resources" will be carried out on May 31st 2016 at Rectorate Building, Pattimura University. There are 200 participants from lecturers, research institute, students, and also there are 34 papers will be presented.

My special thanks refer to the rector of Pattimura University and the Dean of MIPA Faculty, Prof. Dr. Pieter Kakissina, S.Pd., M.Si. I also would like to express my deepest gratitude to Prof. Amanda Reichelt-Brushett, M.Sc., Ph.D. ; Kazuhiko Ishikawa, Ph.D. ; Nicolas Hubert, Ph.D. ; Prof. Dr. Kirbani Sri Brotopuspito ; Prof. Dr. Marjono, M.Phil. ; Gino V. Limon, M.Sc., Ph.D. as the keynote speakers.

The last, We hope this international seminar usefull for all of us, especially Mollucas People and very sorry if any mistake. Thank you very much.

Dr. La Eddy, M.Si.
Chairman of Organizing Committee

Opening Remarks
By Dean of Mathematic and Natural Sciences Faculty

I express my deepest gratitude to The Almighty God for every single blessing He provides us especially in the process of holding the seminar until publishing the proceeding of International Seminar in celebrating the 18th anniversary of MIPA Faculty, Pattimura University. The theme of the anniversary is under the title "Natural Sciences for Exploration the Sea-Island Resources". The reason of choosing this theme is that Maluku is one of five areas in Techno Park Marine in Indonesia. Furthermore, it is expected that this development can be means where the process of innovation, it is the conversion of science and technology into economic value can be worthwhile for public welfare especially coastal communities.

Having the second big variety of biological resources in the world, Indonesia is rich of its marine flora and fauna. These potential resources can be treated as high value products that demand by international market. Basic science of MIPA plays important role in developing the management of sustainable marine biological resources.

The scientific articles in this proceeding are the results of research and they are analyzed scientifically. It is expected that this proceeding can be valuable information in terms of developing science and technology for public welfare, especially people in Maluku.

My special thanks refer to all researchers and reviewers for your brilliant ideas in completing and publishing this proceeding. I also would like to express my gratefulness to the dies committee-anniversary of MIPA Faculty for your creativity and hard working in finishing this proceeding, God Bless you all.

Prof. Dr. Pieter Kakisina, S.Pd., M.Si.
Dean of Mathematic and Natural Sciences Faculty

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"The 2nd International Seminar of Basic Science 2016"

Hotel Mutiara Ambon

Contents

LANDSLIDE SUSCEPTIBILITY ANALYSIS USING WEIGHTED LINEAR COMBINATION (WLC) COMBINED WITH THE ANALYTICAL HIERARCHY PROCESS (AHP)

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ABSTRACT

Bone Pantai area is prone to landslides because of topography and land cover changes. Due to heavy rainfall in this area there were landslides resulting damage and human casualties in the end of 2013. Proper analysis and suitable modeling of dangers may reduce the impact of disaster. In this research, a weighted linear combination (WLC) combined with the analytical hierarchy process (AHP) methods were used to analysis the susceptibility. Elevation, slope angle, slope aspect, rivers, roads, rock formations and the land-cover are considered as the landslide-conditioning parameters. These research reviews that, Bone Pantai have 1.12% very high and 36.82% low susceptibility areas. The result was verified by ground truth assessment of existing landslide susceptibility mapping of the location where the accuracy was 80% and overall Kappa statistics was 0.7337.

***Keywords*:** Accuracy, Landslide, Mapping, Susceptibilit

INTRODUCTION

Landslides play an important role in the evolution of landforms and one of the most widespread damaging natural hazard in hilly regions [1], [2]. Bone Pantai (0°21’- 0°28’ S, 123°9’30” - 123°17’30” E) is a hilly area that susceptible to landslides. In 2013, landslides have occurred in this area resulting in damage and human casualties.

Landslide susceptibility mapping is considered to be an effective tool for reducing the damages to people and infrastructures. The effectiveness of decision making is clearly dependent on the quality of the data used to produce the landslide susceptibility map, as well as on the method used for decision making analysis. In the present study, Weighted Linear Combination (WLC) combined with The Analytic Hierarchy Process (AHP), were used to analyze and obtain more accurate and reliable landslide susceptibility map.

MATERIALS AND METHODS

Weighted linear combination (WLC) with The Analytic Hierarchy Process (AHP) Method

WLC technique is a decision rule for deriving composite map using Geographic Information System (GIS) [3]. The weighted linear combination method is performed to derive the final susceptibility values (1).

$$Y(i,j,t)=\sum_{k=1}^{n} w_k X_k(i,j,t), \text{ where} \sum_{k=1}^{n} w_k = 1 \qquad (1)$$

Y (i, j, t) is final susceptibility value for pixel (i, j) and w_k is the linear combination weight for k-th factor, where k = number of data.

The analytic hierarchy process (AHP) method [4]–[6] are used to determine the weight for each factor of lanslide. The AHP consists of following five steps: (i) break down a decision problem into component factors; (ii) arrangement of these factors in a hierarchic order; (iii) assignment of numerical values to determine the relative importance of each factor according to their subjective relevance; (iv) set up of a comparison matrix; and (v) computation of the normalized principal eigenvector, which gives the weight of each factor. In this method, the pair-wise matrix is used and ranking of all parameters is made by a continuous scale ranging from 1/9 to 9. The results of the pair-wise comparison matrix and the factor weights are shown in Table 2. In AHP, an index of consistency, known as the CR (consistency Ratio), is used to indicate the probability that the matrix judgements were randomly generated. This ranges from 0 to 1, CR close to 0 indicates the probability that the matrix's rating was randomly generated. Saaty recommended the CR to be ≤ 0.1 to be valid. The CR in this study is 0.02 (Table 2).

$$CR=\frac{CI}{RI} \qquad (2)$$

Where RI is the average of the resulting consistency index depending on the order of the matrix given by Saaty[4] (Tabel 1) and CI is the consistency index that is expressed in the following equation.

$$CI=\frac{\lambda_{\max}-n}{n-1} \qquad (3)$$

where λmax is the largest eigenvalue and n is the order of the comparison matrix.

Table 1. Random Consistency Indeks (RI)

N	1	2	3	4	5	6	7	8
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41

N	9	10	11	12	13	14	15
RI	1,45	1,49	1,51	1,53	1,56	1,57	1,59

Parameters of landslide

Topography, land cover, rock formations, rivers and roads was a parameters of landslides in this research.

- Topography
  Topography thematic data layers such as elevation, slope angle, and slope aspect were prepared from Digital Elevation Model (DEM).

- The distance above a datum level called elevation. Elevation indicates the potential energy for landslide. Elevation classified into five different classes (Figure 1a); (i) 0 – 500, (ii) 500 – 1000, (iii) 1000 – 1500, (iv) 1500 – 2000, (v) > 2000.
- Slope gradients ranges of 15% - 70% have a large impact on landslides. Slope angle map classified into five different classes (Figure 1b); (i) ≤ 20°, (ii) 20°–40° , (iii) 40°–60°, (iv) 60°–80°,(v) 80°>.
- Slope aspect is the direction of maximum slope of the terrain surface. Slope aspect was divided into nine classes: (i) Flat, (ii) North (N), (iii) North-east (NE), (iv) East (E), (v) South-east (SE), (vi) South (S), (vii) South-west (SW), (viii) West (W), and (ix) North-west (NW) and reclassified based on susceptibility from processed the Sentinel 1b. (Figure 1c).

- Land-Cover

Changes in land cover such as deforestation, cultivation on steep slopes, road construction, forest logging, and fire can have an important impact on landslide activity. Land-cover layer was generated from Landsat 8 (L8) using *Normal Differential Vegetation Indeks* (NDVI)[7]. NDVI is one of the most popular methods for vegetation monitoring[8]. The NDVI can be expressed as [9]–[12].

$$NDVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R} \qquad (4)$$

where ρ_{NIR} is the reflectance radiated in the near-infrared waveband and ρ_R is the reflectance radiated in the visible red waveband of L8 (LC81130602015084LGN00). NDVI classified into five different classes (Figure 1e); (i) 0,75 – 1,00, (ii) 0,50 – 0,75, (iii) 0,25 – 0,50, (iv) 0 – 0,25, and (v) -1 – 0.

- Rock Formation

The landslide mechanisms are mainly controlled by geological conditions[12]–[14]. Geological factors form rock formations used in this study, because each formation has a great tolerance towards the water and landslides. The study area has the following six rock formations.

- Molasa Celebes (QTs) ; conglomerates and breccias composed by various component materials form of pieces of andesite, basalt, granite, dranidiorit, limestone, sandstone and quartz
- Alluvium and coastal sediment (Qal) : sand, clay, mud, gravel and gravel
- Limestone reef (Ql) : uplifted coral limestone and clastic limestone with coral main component
- Formation Sedimentary facies Tinombo (Tets): sandstone with inserts limestone and chert.
- Diorite Bone (Tmb) : quartz diorite, diorite, granodiorite, granite.
- Volcanic rocks Bilungala (Tmbv) : Breccia, tuff and lava composed of andesite, dacite and rhyolite.

The Sixth of rock formation was reclassified based on susceptibility from processed the Sentinel 1b (Figure 1).

- Rivers

Landslides often occur in areas of the river[15], [16]. Rivers was divided into five distance to river classes (Figure 1d): (i) 150m, (ii) 120m, (iii) 90m, (iv) 60m, (v) 30m.

- Roads

A road constructed beside the slopes causes a increase in the load on the heel of the slope, it cause landslides may occur on the road and on the side of the slopes affected [17], [18]. Such as rivers, roads was divided into five distance to road classes (Figure 1f): (i) 150m, (ii) 120m, (iii) 90m, (iv) 60m, (v) 30m.

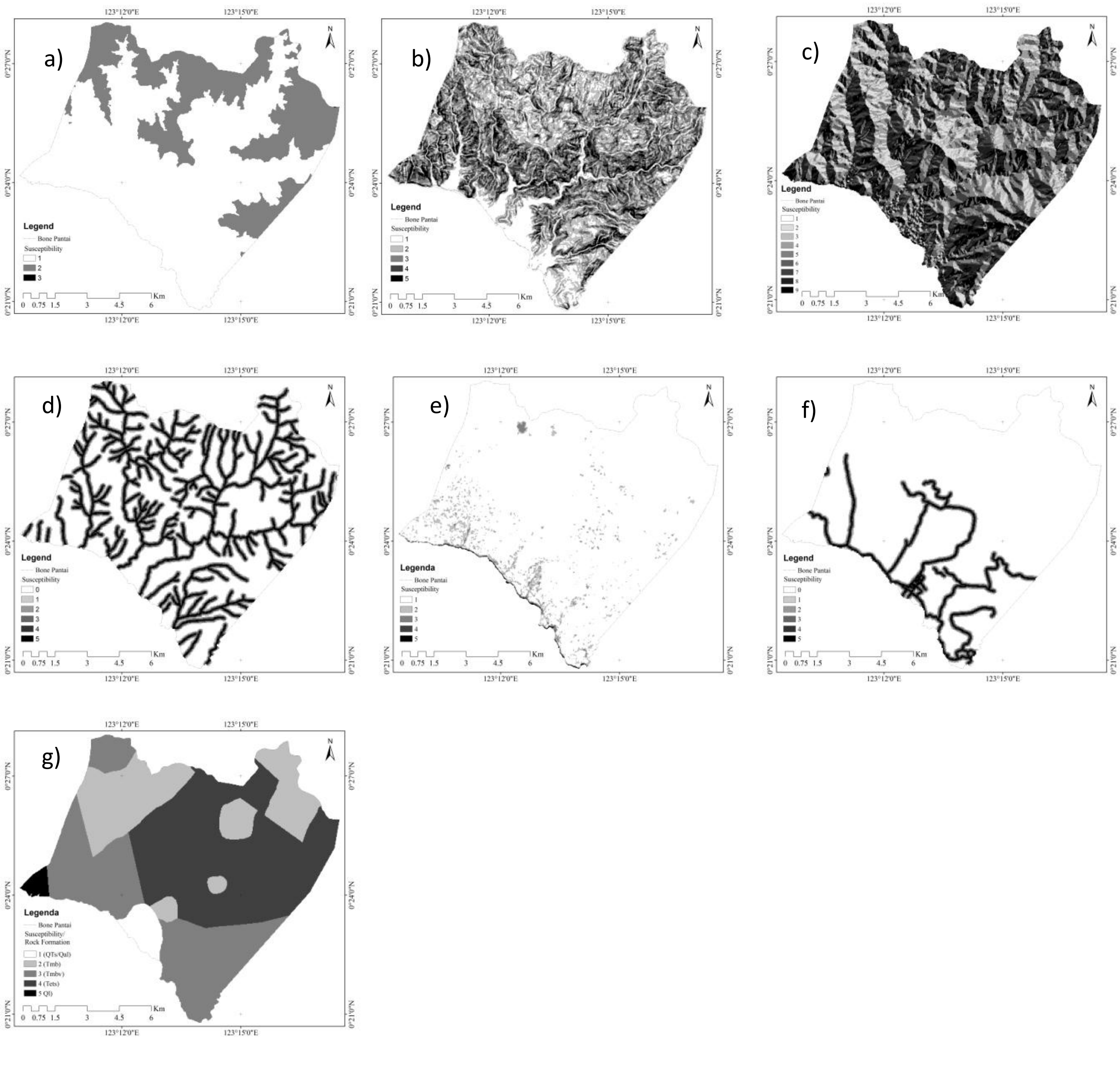

Figure 1. Parameters of landslide; a) Elevation, b) Slope gradient, c) Slope aspect, d) Rivers, e) Land-cover, f) Roads, g) Rock Formations

Model Assessment

In this research, the kappa index value are used to show the similarity between the susceptibility maps with ground truth assessment. Equation (5) is The kappa coefficient[19].

$$\hat{k} = \frac{p_0 - p_c}{1 - p_c} \quad (5)$$

where p_o is percentage number of inter-rater consistency measurement and p_c percentage number of inter-rater measurement changes. The kappa ranges from 0.0 to 1.0. A Kappa value of 1 indicates a perfect similarity between the model and ground truth assessment of existing landslide location.

RESULTS AND DISCUSSION

The pair-wise matrix is used and ranking of all parameters of landslide using the AHP method resulted rock formations is the most heavily weighted parameter followed by land-cover and slope angle (Table 2).

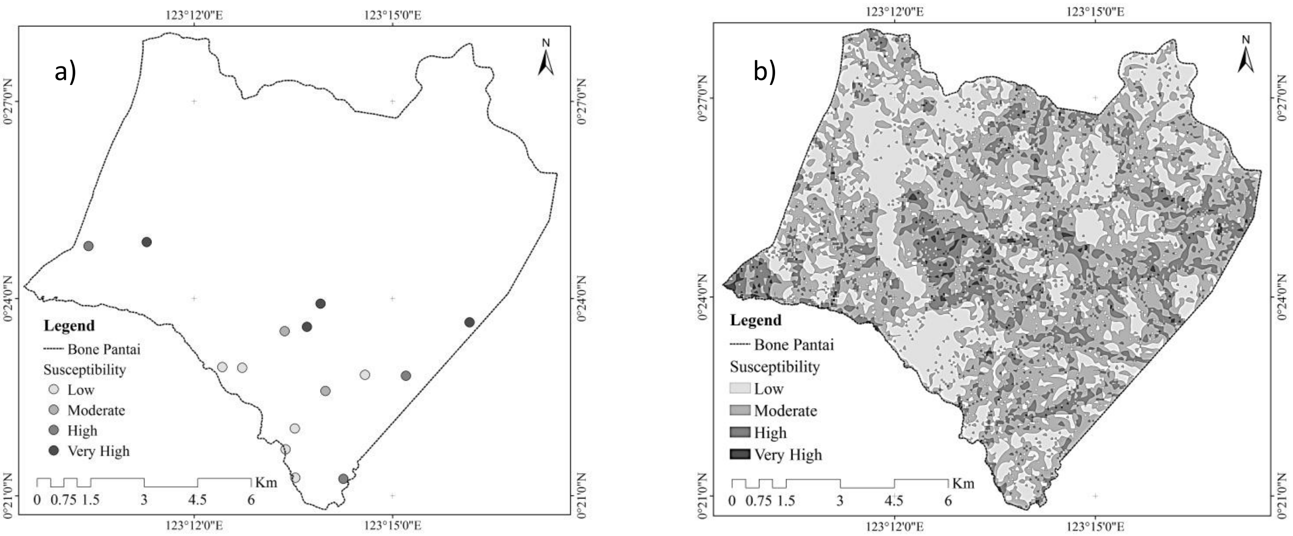

Figure 2. Landslide Susceptibility Map of Bone Pantai: a) ground truth, b) The Wlc-Ahp Method.

Table 2. The Pair-Wise Comparison Matrix, Parameter Weights And Consistency Ratio Value.

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	W
X_1	1.00							0.089
X_2	2.44	1.00						0.176
X_3	1.17	0.79	1.00					0.104
X_4	1.19	0.87	1.43	1.00				0.114
X_5	2.03	0.87	2.69	2.47	1.00			0.210
X_6	1.15	0.56	0.65	0.73	0.48	1.00		0.084
X_7	1.94	1.10	2.10	2.50	0.97	3.65	1.00	0.224

Consistency ratio (*CR*): 0.02 < 0.1 (acceptable)

Based on the weighted (w) parameters and WLC method, mathematical equation of landslides (6) and landslide susceptibility map was produced (Figure 2b). The map shows that, Bone Pantai have 36.82% low, 45.10% moderate, 16.97% high and 1.12% very high susceptibility areas. The result was verified by ground truth assessment of existing landslide location (Figure 2a) where the overall accuracy was 80% and kappa statistic 0.7337.

$$Y = (0.089X_1) + (0.176X_2) + (0.104X_3) + (0.144X_4) + (0.210X_5) + (0.084X_6) + (0.224X_7) \quad (6)$$

where Y is final susceptibility, X_1 is elevation, X_2 is slope angle, X_3 is slope aspect, X_4 is rivers, X_5 is land-cover, X_6 is roads, and X_7 is rock formations.

CONCLUSION

A reliable and accurate susceptibility map depends on the role of reviews these parameters and methods. Seven landslide-controlling parameters items, namely elevation, slope angle, slope aspect, land-cover, rock formations, rivers and roads were analyzed used the WLC-AHP method that can sufficiently represents the landslide susceptibility map in this research. Bone Pantai is still safe from landslide based on this research. Landslide studies with other methods are needed to improve the accuracy of the landslide susceptibility map in the Bone Pantai subdistrict.

REFERENCES

[1] B. D. Malamud, D. L. Turcotte, F. Guzzetti, and P. Reichenbach, “Landslide Inventories and Their Statistical Properties,” *Earth Surf. Process. Landforms*, vol. 29, pp. 687–711, 2004.

[2] H. Reza, M. Mohammady, and B. Pradhan, “Catena Landslide susceptibility mapping using index of entropy and conditional probability models in GIS : Safarood Basin , Iran,” *Catena*, vol. 97, pp. 71–84, 2012.

[3] A. Akgun, “GIS-based landslide susceptibility for Arsin-Yomra (Trabzon , North Turkey) region,” *Env. Geol*, vol. 51, pp. 1377–1387, 2007.

[4] T. Saaty, L., “A Scaling Method for Priorities in Hirarchical Structures,” *Mat. Psychol.*, vol. 15, pp. 234–281, 1977.

[5] T. Saaty, L., “How to make a decision: The Analitic Hierachy Prosess,” *Eur. J. Oper. Res.*, vol. 48, pp. 9–26, 1990.

[6] T. Saaty, L., “Decision making with the analytic hierarchy process,” *Int. J. Serv. Sci.*, vol. 1, pp. 83–98, 2008.

[7] C. J. van Westen, E. Castellanous, and S. L. Kuriakose, “Spatial data for landslide susceptibility , hazard , and vulnerability assessment : An overview,” *Eng. Geol.*, vol. 102, no. 3–4, pp. 112–131, 2008.

[8] C. J. Van Westen, “3 . 10 Remote Sensing and GIS for Natural Hazards Assessment and Disaster Risk Management,” in *Reference Module in Earth Systems and Environmental Sciences*, vol. 3, Elsevier Ltd., 2013, pp. 259–298.

[9] H. Hong, B. Pradhan, C. Xu, and D. Tien, “Catena Spatial prediction of landslide hazard at the Yihuang area (China) using two-class kernel logistic regression , alternating decision tree and support vector machines,” *Catena*, vol. 133, pp. 266–281, 2015.

[10] F. Pirotti, A. Parraga, E. Stuaro, M. Dubbini, A. Masiero, and M. Ramanzin, “NDVI From Landsat 8 Vegetation Indeces To Study Movement Dynamics of C,” *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. XL–7, no. October, pp. 147–153, 2014.

[11] B. Pradhan and S. Lee, “Utilization of Optical Remote Sensing Data and GIS Tools for Regional Landslide Hazard Analysis Using an Artificial Neural Network Model,” *Earth Sci. Front.*, vol. 14, no. 6, pp. 143–152, 2007.

[12] B. Pradhan and S. Lee, “Environmental Modelling & Software Landslide susceptibility assessment and factor effect analysis : backpropagation artificial neural networks and

their comparison with frequency ratio and bivariate logistic regression modelling," *Environ. Model. Softw.*, vol. 25, no. 6, pp. 747–759, 2010.
[13] L. Wang, M. Guo, K. Sawada, J. Lin, and J. Zhang, "Catena Landslide susceptibility mapping in Mizunami City , Japan : A comparison between logistic regression , bivariate statistical analysis and multivariate adaptive regression spline models," *Catena*, vol. 135, pp. 271–282, 2015.
[14] S. Yoshimatsu, H. Abe, "A review of landslide hazards in Japan and assessment of their susceptibility using an analytical hierarchic process (AHP) method," *Landslide*, vol. 2, no. March 2005, pp. 149–158, 2006.
[15] L. Ayalew, H. Yamagishi, and N. Ugawa, "Landslide susceptibility mapping using GIS-based weighted linear combination , the case in Tsugawa area of Agano River , Niigata Prefecture , Japan," *Landslide*, vol. 1, pp. 73–81, 2004.
[16] M. Rinaldi, N. Surian, F. Comiti, and M. Bussettini, "Geomorphology A methodological framework for hydromorphological assessment , analysis and monitoring (IDRAIM) aimed at promoting integrated river management," *Geomorphology*, 2015.
[17] A. K. Pachauri and M. Pant, "Landslide hazard mapping based on geological attributes," *Eng. Geol.*, vol. 32, pp. 81–100, 1992.
[18] U. Kamp, B. J. Growley, G. A. Khattak, and L. A. Owen, "Geomorphology GIS-based landslide susceptibility mapping for the 2005 Kashmir earthquake region," *Geomorphology*, vol. 101, pp. 631–642, 2008.
[19] G. M. Foody, "Thematic map comparison: evaluating the statistical significance of differences in classification accuracy," *Photogramm. Eng. Remote Sens.* , vol. 70, no. 5, pp. 627–633, 2004.