Analysis of spatial distribution of habitat *Oncomelania hupensis* using Landsat ETM data in Lindu plain, Central Sulawesi

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**Abstract.** Transmission *Schistosomiasis Japonicum*, parasite disease by *Schistosoma* worm infection is closely related to the distribution of slugs *Oncomelania Hupensis Linduensis*. Spatial deployment of snail habitats can be traced through the geographical characteristics of their lives. This research was conducted to build spatial analysis model of the distribution of snail habitat using Landsat data to extract vegetation index information (NDVI), land humidity index (TVDI), land cover, with data supporting land inclination, altitude, distance from the river, distance from the lake, soil surface, and rainfall. Research conducted in the Lindu Plains was analyzed by stepwise regression to identify the ecological determinants of *Oncomelania Hupensis Linduensis* life. The results show that TVDI, land coverage, NDVI, and LST are the most significant variables with 85.9% correlation and 87.03% accuracy. From the modeling analysis, it is known that *Oncomelania Hupensis* habitat distribution shows a random pattern. By knowing the characteristics of *Oncomelania Hupensis* habitat distribution through remote sensing analysis, it is expected to monitor the movement of the habitat, so that the step can be used to help control the habitat referred to as host of *Schistosomiasis* disease in Indonesia.

1. **Introduction**

*Schistosomiasis* is one of the parasitic diseases that are classified as dangerous in public health. According to WHO (2001) [1]. The spread of the disease is quite extensive in developing countries, both tropical and subtropical [2]. *Oncomelania Hupensis Linduensis* has been known as an intermediate snail of *Schistosomiasis* in Indonesia since it was first discovered around grass growing in abandoned paddy fields in Paku, Anca, Lindu Highlands in 1971. The name of the snail species belonging to the Bithyniidae family was given two years then by David and Carney having previously been identified and compared their morphology with other *Oncomelania* present in some Asian countries [3].

The Geographical Information System (GIS) application can be applied to identify the distribution of *Oncomelania Hupensis* habitat by overlay analyzing through modeling of spatial data related to snail *Oncomelania Hupensis*. The results of his analysis may provide information on the distribution of infection risks to guide the intervention of *Schistosomiasis* disease. The rate of infection in snails in *Schistosomiasis* transfers is higher than in humans [4]. Snack habitats of *Oncomelania Hupensis*
Lindoensis are found in agricultural areas such as rice fields, plantations, forests, along with irrigation, and often flooded areas of the meadows [5]. Habitats favored by snails Oncomelania Hupensis Lindoensis are muddy mud spots throughout the year under direct sunlight, traces of abandoned plants for a long time, the debris of the muddy drains surrounding them, and the edge of the forest where the grass is protected from constantly moist and watery sunshine [6,2].

The research applied in Lindu Plateau, Sigi, Central Sulawesi was aimed to explore the possibility of an optimal geographic-environment factor for life and growth of snail Oncomelania Hupensis Lindoensis using Landsat ETM data and other spatial data through a stepwise regression model.

2. Materials and Method

The Lindu Plateau is located in Lindu district, geographically positioned at 1° 13'37 "- 1° 30'15" LS and 120 ° 00'43 "- 120° 17'17" BT. Administratively it consists of 5 villages, directly adjacent to Poso district. To go to Lindu region can only be reached by two-wheeled vehicles (motorcycles) and on foot. Lindu District is generally a mountainous area (about 90.0%) and is in the Lore Lindu National Park Area at an altitude of 700-2400 meters above sea level (Figure 1).

Snapshot samples from Oncomelania Hupensis Lindoensis were carried out to determine the snails that had been infected by Schistosomiasis worms. Determination of the sample is based on areas that have snail habitat characteristics, determination of the density of Oncomelania Hupensis snails, using samples measuring 0.11 m² in some focus, snail habitat [7,8]. Samples are then analyzed in a laboratory to determine the prevalence of infected snails.

Normalized Difference Vegetation Index (NDVI), Temperature Vegetation Dryness Index (TVDI), and land cover, and the distance from the lake is extracted from Landsat ETM image analysis in 2017 (Figure 2), Slope, altitude, and river tilt data is extracted from the available 30 meter available Web Radar Topography Mission (SRTM) data. While the rainfall is analyzed based on the average rainfall data of 2017 from the Meteorology, Climatology and Geophysics Agency (BMKG). Land Surface
Temperature (LST) was analyzed from the United States Geological Survey data Landsat [9]. The surface temperature is related to the growing conditions of Oncomelania Hupensis, and it is strongly associated with the abundance of snails [10].

A stepwise regression analysis was used to identify significant geographic-environment covariance related to snail distribution, with a stepwise linear regression equation. Multiple linear regression is an equation that describes the relationship between over one independent variable \((X_1, X_2, \ldots, X_n)\) and one independent variable \((Y)\). Mathematically the relationship of these variables can be written as follows [11].

\[
Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k + \varepsilon
\]

Where: \(Y\) = independent variable (in this research context is snail density), \(X\) = independent variable (in this study is \(X_1 = NDVI, X_2 = LST, X_3 = TVDI, X_4 = Land \text{ cover}, X_5 = elevation, X_6 = \text{slope}, X_7 = \text{distance from river}, X_8 = \text{distance from lake}, \) and \(X_9 = \text{Rainfall})\). \(\beta_0\) = regression constant, \(\beta_1, \beta_2, \ldots, \beta_k\) = regression parameter, \(\varepsilon\) = residual estimate.

Stepwise regression involves two types of processes: forward selection and backward elimination. At each stage, there is a process of deciding which variable is the best predictor to put into the model. This is determined by \(F_{\text{partial}}\) test. If the \(F_{\text{partial}}\) value of the inserted variable is smaller than the specified \(F_{\text{table}}\) value then the variable is omitted. This process is done continuously until no more variables meet the criteria to be added or eliminated [12].

After obtaining a stable \(F\) test result variable, spatial autocorrelation analysis with Global Moran’s formula [13] was conducted to evaluate whether the results showed clustered, dispersed, or random patterns. The results of the analysis of the extent of clustering of the snail habitat distribution are indicated by the Moran’s Index value of spatial correlation analysis. The Moran’s Global Formula is:

\[
I_i = Z_i \sum_j W_{ij} Z_j
\]

where \(I_i\) is the Moran’s Index; \(Z\) and \(Z_i\) are deviations from Mean, features \(i\) and \(j\); and \(W_{ij}\) is the weight of features \(i\) and \(j\).

3. Result
A total of 9 variables were analyzed using two criteria, namely, VIF and tolerance. Acceptance criteria are tolerance values <0.1 and VIF > 10. The results of multicollinearity analysis, it can be concluded that there is no multicollinearity, the slope variable in the analysis has a tolerance value of <0.1 and VIF > 10, so that it is removed from the subsequent process analysis. The tolerance value and final VIF of the 8 parameters can be seen in Table 1.

| Model       | Unstandardized Coefficients (B) | Standardized Coefficients (β) | t      | Sig. | Tolerance | VIF |
|-------------|---------------------------------|-------------------------------|--------|------|-----------|-----|
| 1 (Constant)| -622.215                        | -1.738                        | 0.09   |      |           |     |
| NDVI        | 123.466                         | 0.159                         | 2.068  | 0.046| 0.559     | 1.79|
| LST         | -14.388                         | 0.157                         | 2.511  | 0.016| 0.845     | 1.183|
| TVDI        | -246.879                        | -0.702                        | -6.554 | 0.000| 0.287     | 3.482|
| Land cover  | -7.425                          | -0.197                        | -2.871 | 0.007| 0.701     | 1.427|
| Elevation   | 0.538                           | 0.183                         | 1.839  | 0.074| 0.332     | 3.015|
| Dist from river | -0.004                     | -0.031                        | -0.441 | 0.662| 0.656     | 1.525|
| Dist from lake   | -0.005                        | -0.116                        | -1.198 | 0.238| 0.349     | 2.866|
| Rainfall     | 0.116                           | 0.156                         | 1.743  | 0.089| 0.413     | 2.419|

Screening of variables that have a significant effect on snail habitat involves a series of screening processes that meet the model criteria. From the second stage filtration obtained variable that meets the criteria model, \(X_1 = NDVI, X_2 = LST, X_3 = TVDI, X_4 = Land \text{ cover} \). This stage shows that four independent variables, namely NDVI, LST, TVDI, and land cover, all of which have significant
significance (Sig. or p-value) < 0.05 are important variables underlying the presence of snails [14]. For the next stage, the third stage is to process the four variables in the analysis continued.

Based on the analysis of the third stage, it was found that the geographic-environment variable that has a great influence on the snail density, from the calculation in Table 2, it is known that the best variables in predicting the existence of snail habitat Oncomelania Hupensis Lindoensis are TVDI, land cover, NDVI, and LST. LST variable gives the highest correlation, that is 0.859 with 87.03% accuracy level of the model.

| Model   | Unstandardized Coefficients (B) | Standardized Coefficients (β) | t   | Sig.  | R²      | Std error of the estimate |
|---------|---------------------------------|--------------------------------|-----|-------|---------|--------------------------|
| (Constant) | 1.259                           |                                | 1.77 | 0.044*|         |                          |
| TVDI    | -3.368                          | -0.792                         | -11.819 | 0.000**|         |                          |
| Land cover | -0.063                         | -0.139                         | -2.275 | 0.028*|         |                          |
| NDVI    | 1.734                           | 0.184                          | 2.623 | 0.012*|         |                          |
| LST     | -0.137                          | 0.124                          | 2.106 | 0.041*| 0.859   | 12.9668                  |

*Significant correlation at the 0.05  
**Significant correlation at the 0.01  
***The model's accuracy is 87.03%

TVDI variables have a negative relationship to the presence of snails, which means that high humidity with low (moist) TVDI index is an appropriate location in the Oncomelania Hupensis proliferation. The value of NDVI affects the snail density, this is judged by the high NDVI value increases the snail density, this is because the density of vegetation gives the effect of moisture on the soil [8]. The LST values defined in the previous study [7] are not in line with this study, due to differences in geographical conditions of Indonesia with different China, resulting in differences in temperature values.

Based on the analysis of spatial autocorrelation of samples taken at the snail location, it was seen that the distribution of snails was randomly distributed with a z value = 0.0313. Thus it can be concluded that there is no spatial autocorrelation in the distribution of snails found in the Lindu District. While the Moran Index value = -0.021, that means the relationship is negative. This means that there is no spatial autocorrelation. It can be concluded that there are other variables in determining the presence of snails in addition to the geographical-environmental variables used in this study which encourage the proliferation of snails in the study location. The non-existence tendency is based on the fact that the field found that some Oncomelania Hupensis habitat points are located in several springs and seepage with low (humid) TVDI values. In addition, the distribution of snails is spread in locations that have not been logged.

The model performance developed in this study was evaluated by kappa coefficients based on samples taken randomly in the study area. Based on the analysis, the value of kappa = 0.8. This means that models built with variable NDVI, LST, TVDI, and land cover perform very well in predicting the spatial distribution of snail habitat Oncomelania Hupensis Lindoensis in the study area (Figure 4).

Many studies use remote sensing data and geographic information systems combined with statistical analysis to determine geographic-environment variables related to snail habitat Oncomelania Hupensis Lindoensis as an intermediary of Schistosomiasis, as did by Cheng et al, Guo et al, Wang et al, Wu et al, Zhang et al, Zang et al, and Zhu et al [15,16,7,14,17,18,19,20].
4. Conclusions

Identification of spatial distribution of snail *Oncomelania Hupensis Lindoensis* can be done by Landsat ETM data analysis approach and spatial data support using geographic information system. The results showed that TVDI, land coverage, NDVI, and LST were the most significant variables in determining the presence of *Oncomelania Hupensis Lindoensis* snail habitat with 85.9% correlation and 87.03% accuracy. From the analysis of modeling known that the distribution of *Oncomelania Hupensis Lindoensis* habitat showed a random pattern. By knowing the characteristic of habitat distribution of *Oncomelania Hupensis Lindoensis* through remote sensing analysis, it is expected to monitor the movement of the habitat, so that the step can be used to help control the habitat as host of *Schistosomiasis* disease in Indonesia, especially in Lindu high land, Sulawesi.

Drying of paddy fields, hardening of channels and rotation of paddy fields to dry farms is potentially effective in radically altering snail habitat conditions by destroying the ecological environment of *Oncomelania Hupensis Lindoensis*.

The use of *Baylucide* sprays requires a lot of costs compared to environmental modifications in addition to repeated spraying can pollute the environment, however, environmental modification saves resources due to its long-term stable effects and also does not produce environmental pollution. Then the method of environmental modification is good enough to be applied in Lindu District.
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References

[1] Blancard. T. J 2004 Schistosomiasis *Travel Medicine and Infectious Disease* 2 pp 5-11

[2] Erlan, A., Junaidi, M., Nyoman, N., Puryadi., Octaviani 2014 Study on *Chistosomiasis* Control Policy in Poso Regency and Sigi Regency in Central Sulawesi Province in 2012 *Media Litbangkes* Volume 24 No 1 page 42-49

[3] Garjito, T.A., Jastal., Mujiyanto., Widjaja, J., Udin, Y., Maksud, M., Kurniawan, A 2014 Distribution Habitat *Oncomelania Hupensis Lindoensis* Intermediate *Schistosoma Japonicum* in the Highlands of Lindu Sigi Central Sulawesi *Bulletin Penelitian Kesehatan* Volume 42 No 3 Sep 2014 page 139-152

[4] Zhou, X.N., Sun, L.P., Jiang, Q.W., Guo, J.G., Wang, T.P., Lian, D.D., Yang, G.J., Hong, Q.B., Huang, Y.X., Zhang, S.Q., Wang, Q.Z., Hu, F 2000 GIS spatial analysis on a transmission of schistosomiasis in China *J. Epidemiol* 21 261–263

[5] Hafsah 2013 Karakteristik Habitat dan Morfologi Siput *Oncomelania Hupensis Lindoensis* sebagai Hewan Reservoir dalam Penularan Schistosomiasis pada Manusia dan Ternak di Taman Nasional Lore Lindu. *J.Manusia dan Lingkungan* Vol 20 No 2 pp 144-152

[6] Sudomo, M. and M.D.S. Pretty 2007 Schistosomiasis Control in Indonesia *Buletin Penelitian Kesehatan*, Vol 35 No 1 pp 36-45

[7] Lin, T., & Lin, D 2001 Classification study on the marshland in an endemic area of *Schistosoma Japonicum* using satellite TM images data *Chin J. Prev. Med* 35 312–314

[8] Guo, J.G., Vounatsou, P., Cao, C.L ., Jurg, U., Zhu H.Q., Daniel, A., Zhu, R., He Z.Y., Li, D., Hu, F., Chen M.G., Marcel, T 2005 A geographic information and remote sensing based model for prediction of *Oncomelania Hupensis* habitats in the Poyang Lake area China *Acta Tropica* 96 pp 213–222

[9] USGS, 2013. Using the USG Landsat 8 Product Online Maret 18 2018 Available at http://landsat.usgs.gov Using Product Php

[10] Kristensen, T.K., Malone, J.B., McCarrorrc, J.C 2001 Use of Satellite Remote Sensing and Geographic Information Systems to Model the Distribution and Abundance of Snail Intermediate Hosts in Africa: a Preliminary Model for *Biomphalaria Pfeiffer* in Ethiopia *Acta Tropica* 79 pp 73–78

[11] Waypole, R.E., Myers, R.H., Myers, S.L., Ye, K 2012 *Probability & Statistics for Engineer & Scientists* 9th ed Deirdre Lynch USA: Pearson Education p 447

[12] Draper, N. R., & Smith, H 1998 *Applied regression analysis* 3rd New York John Wiley & Sons Chap 15

[13] ESRI. 2002. Using *ArcGIS* Spatial Analyst. April 16, 2018 Available at http://desktop.arcgis.com Using Product

[14] Yang, K., Wang, X.H., Yang, G.J., Wu, X.H., Qi, Y.L., Li, H.J., Zhou, X.N 2008 An integrated approach to identifying a distribution of Oncomelania Hupensis, the intermediate host of Schistosoma Japonicum, in a mountainous region in China. *International Journal for Parasitology* 38 1007-1016

[15] Cheng, G., Li, D., Zhuang, D., Wang, Y 2016 The influence of Natural Factors on the Spatio-temporal Distribution of *Oncomelania Hupensis Acta Tropica* 164 pp 194-207

[16] Wang, J.G.; Liao, H.Y.; Zhong, G.T.; Yu, B.G.; Huang, S.S 2002 Observation on the effect of schistosomiasis through snail control by environmental modification *Chin J. Schist* 14 pp 200-202
[17] Wu, J.Y., Zhou, Y.B., Li, L.H., Zheng, Sb., Liang, S., Coatsworth, A., Ren, G.H., Song, X.X., He, Z., Cai, B., You, J.B., Jiang, W.Q 2014 Identification of optimum scopes of environmental factors for snails using spatial analysis techniques in Dongting Lake region China Parasites Vectors Volume 7 No 1 page 1–12
[18] Zhang, Z., Zhong, X.D., Zhou, X.N., Yun, Z., Liu, S.J 2005 Remote Sensing and Spatial Statistica Analysis to Predict the Distribution of Oncomelania hupensis in the Marshlands of China Acta Tropica. 96 205-212
[19] Zhang, Z., Seng, H.O., Peng, W., Zhou, Y., Zhuang, J., Zhao, G., Jiang, Q 2008 A Model for the Predicting of Oncomelania Hupensis in the Lake and Marshland regions China Parasitology International 57 121-131
[20] Zhu, H.R., Liu, L., Zhou, X.N., Yang, G.J 2015 Ecological model to predict potential habitats of Oncomelania hupensis, the intermediate host of schistosoma japonicum in the mountainous regions China. PLoS Negl. Trop. Dis. 9 (8)