Engineering and Technology Journal e-ISSN: 2456-3358

Volume 11 Issue 05 May-2026, Page No.-10024-10030

DOI: 10.47191/etj/v11i05.37, I.F. – 8.595

Correlation Between Forest Cover Loss and Static Groundwater Levels in Laur, Nueva Ecija, Philippines

Angelo Jasper G. Esguerra[1], Dheejay Steven F. Glemao[2], Gianne Mickaela V. Jacamile[3], Laira Mae P. Javier[4], Mark Nichoel M. Santiago[5], Cheska Angeline Velasco[6], Rosel V. Babalcon[7]

[1,2,3,4,5,6,7]Nueva Ecija University of Science and Technology, Sumacab Este, Cabanatuan, Nueva Ecija

ABSTRACT: This study examined the relationship between forest cover loss and Static Water Level (SWL) depth fluctuations in Laur, Nueva Ecija, Philippines from 2015 to 2026 using secondary environmental data and Pearson correlation analysis. Forest cover data from the Municipal Environment and Natural Resources Office (MENRO) and SWL records were analyzed to identify trends in vegetation loss and groundwater conditions within the Sierra Madre boundary. Higher SWL depth values indicate deeper groundwater tables and potentially lower groundwater availability. Results showed fluctuations in both forest cover loss and SWL depth during the study period. Statistical analysis revealed a significant negative correlation between forest cover loss and SWL depth ($r = -0.7893$, $p = 0.003868$), indicating an inverse relationship between the variables. Periods of higher forest cover loss were associated with changes in groundwater depth, while lower forest loss corresponded with different SWL conditions. However, the findings are limited to statistical association and do not establish causation. The study supports existing literature suggesting that forest cover influences watershed processes such as infiltration and groundwater recharge. Overall, the study provides baseline information for future environmental monitoring and watershed management in Laur, Nueva Ecija.

KEYWORDS: Static Groundwater Levels, Forest Cover Area, Pearson’s Correlation Coefficient (r), Municipality of Laur, Nueva Ecija, Geotechnical Engineering, Secondary Data.

I. INTRODUCTION

A. Background of the study

The Municipality of Laur, situated at the foothills of the Sierra Madre mountain range in Nueva Ecija, occupies a distinctive hydrogeological niche characterized by extensive alluvial formations. These geological units serve as critical recharge zones due to their high porosity and permeability, which facilitate the percolation of meteoric water into local aquifers. However, the efficacy of this recharge mechanism is intrinsically linked to the ecological integrity of the upland watershed. Forest ecosystems function as hydrological regulators; specifically, tree canopies and root systems provide a "biological sponge" effect that mitigates rainfall kinetic energy and enhances deep soil infiltration (Laur LGU; Abon & David, 2016).

While freshwater constitutes only 2.5% of global water resources (WMO, 2019), its localized availability in Laur is increasingly threatened by anthropogenic land-cover transitions within the Sierra Madre. The conversion of primary forests into agricultural plots or open spaces disrupts the infiltration-runoff balance. In the absence of vegetative cover, reduced soil hydraulic conductivity increases surface runoff, subsequently accelerating soil erosion and the transport of fine-grained silts into lowland basins. This sedimentation process potentially diminishes soil permeability, thereby impairing long-term subsurface water flux and groundwater storage.

Recent data indicate that the degradation of the Southern Sierra Madre—marked by an annual loss of thousands of hectares—may be associated with changes in hydrological conditions (The Philippine Star, 2025; Gabriel et al., 2025). The

loss of the forest "sponge" mechanism may be associated with reduced aquifer recharge rates, which in turn has been associated in literature with increased flash flooding during the wet season and lower groundwater conditions during the dry season (Bawafi et al., 2020; Tumbaga, 2023).

Furthermore, the vulnerability of Laur is compounded by the risk of aquifer-system compaction and land subsidence. As groundwater extraction intensifies to offset the deficit in surface water, the region risks mirroring the subsidence-driven disasters observed in Metro Manila (Eco et al., 2020; Jago-on et al., 2021). Consequently, integrating geospatial analysis with reforestation strategies is essential to mitigate the long-term+ depletion of groundwater resources and ensure the hydrological sustainability of the region (Manuel & Velasco, 2021; Mainstreaming DRR, 2021).

B. Objectives of the Study

1. Quantify the forest cover loss within the Sierra Madre boundary of Laur, Nueva Ecija from 2015 to 2026.
2. Analyze the trends in Static Water Level (SWL) depth using SWL data from MENRO-Laur.
3. Determine the statistical relationship between forest cover loss and SWL depth using correlation analysis.
4. Assess the possible implications of forest cover loss on SWL depth fluctuations in Laur, Nueva Ecija.

C. Scope and Delimitations

This study focuses on the Municipality of Laur, Nueva Ecija, specifically within the Sierra Madre boundary, to examine the relationship between forest cover changes and Static Water Level (SWL) depth. Utilizing secondary data from MENRO (2015–2026), the research analyzes temporal trends to determine the statistical correlation between these variables. The scope is limited to secondary data analysis; it excludes field measurements, experimental validation, water quality assessment (biological or chemical), and industrial aquifers. Additionally, this assessment centers on forest canopy extent as the primary explanatory variable; however, it remains agnostic toward the confounding effects of pluviometric variability, groundwater withdrawal velocities, and broader agrostological or urban land-use transitions. Consequently, the findings identify statistical associations rather than establishing direct causation.

The study is further limited by a small sample size (n = 12 years), which may affect the stability and generalizability of the statistical results. Therefore, the findings are exploratory in nature and should be interpreted with caution.

D. Conceptual Framework

This study adopts an Input–Process–Output (IPO) model to illustrate the relationship between forest cover loss and Static Water Level (SWL) depth in Laur, Nueva Ecija. The framework presents how environmental data are transformed into measurable findings through statistical analysis. While this study posits a relationship between forest cover area loss and SWL depth, the correlation analysis is exploratory and limited by sample size and absence of control variables. Consequently, the framework serves to identify potential trends within the specific context of Laur, Nueva Ecija, rather than asserting universal causality.

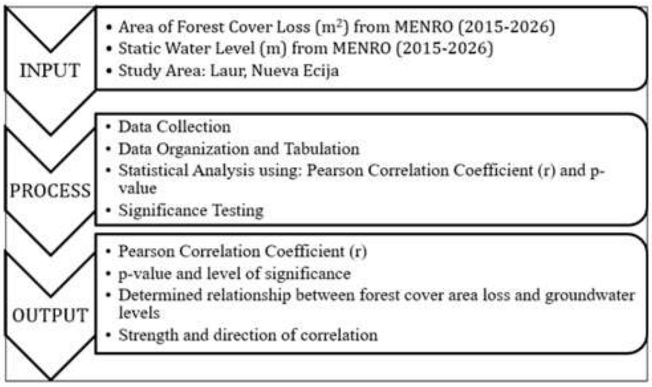

Figure 1. The Input-Process-Output Model

This study employs an Input–Process–Output (IPO) framework to analyze the hydrological impact of deforestation in Laur from 2015 to 2026. The Input comprises longitudinal data from MENRO, specifically forest cover loss (m^2) and Static Water Level (SWL) depth (m). The Process utilizes Pearson Correlation (r) and p-value analysis to objectively quantify the relationship between these variables. Consequently, the Output yields a statistical interpretation of correlation strength and significance, establishing an empirical basis for understanding the interaction between forest cover area and SWL depth.

II. REVIEW OF RELATED LITERATURE

Previous studies have consistently shown that forest cover and land use change influence watershed hydrology and groundwater recharge processes. International studies by Singh et al. (2022), Mapulanga and Naito (2019), Bawafi et al. (2020), and Ranjan et al. (2006) reported that deforestation and land conversion may reduce infiltration, increase runoff and sedimentation, and alter groundwater recharge dynamics. Similarly, Ilstedt et al. (2016) and Oliveira et al. (2017) emphasized that vegetation density and land-cover conditions significantly affect groundwater recharge behavior, although hydrologic responses vary with climate, vegetation structure, and watershed conditions. These studies collectively suggest that forest cover plays an important role in maintaining watershed hydrologic balance and groundwater sustainability.

In the Philippine context, GIS-based and watershed-related studies similarly indicate that forest degradation and land cover change may affect groundwater recharge and watershed conditions. Sandoval and Tiburan Jr. (2021), DLSU Research Team (2022), and Tañagras et al. (2023) demonstrated the usefulness of GIS and spatial analysis in assessing recharge potential, watershed vulnerability, and hydrologic responses to land cover change. Pulhin et al. (2024) and Dessie and Bredemeier (2013) further noted that deforestation and vegetation loss may influence infiltration, runoff behavior, sediment transport, and groundwater recharge potential in Philippine watersheds. Meanwhile, PCAARRD-DOST (2024) reported that many Philippine watersheds continue to experience environmental pressures from deforestation, agricultural expansion, and land conversion, which may threaten long-term water sustainability.

Within Nueva Ecija, studies involving the Dupinga Watershed, Pantabangan-Carranglan Watershed, and Minalungao National Park suggest that forest disturbance and land cover change may influence watershed conditions, groundwater recharge, and ecological stability. Gabriel et al. (2025), Manuel and Velasco (2021), Dida et al. (2021), and Tumbaga (2023) emphasized the importance of forest conservation, reforestation, and remote sensing-based monitoring in maintaining watershed functions and environmental sustainability. Collectively, the reviewed literature suggests that forest cover change may be associated with variations in groundwater conditions and watershed hydrology. However, limited localized studies have quantitatively examined the relationship between forest cover loss and Static Water Level (SWL) depth fluctuations in Laur, Nueva Ecija using available environmental datasets, highlighting the need for localized correlation-based assessment.

III. METHODOLOGY

The replenishment of groundwater within aquifers is an important component of regional resource sustainability, supporting potable water supply, agricultural irrigation, and industrial activities—particularly in the Philippines, where surface water availability may vary seasonally. This study utilizes geospatial and geological classification to categorize the study area into distinct environmental zones. In addition, a temporal analysis of Static Water Level (SWL) depth records in Laur, Nueva Ecija was conducted to identify trends in groundwater conditions from 2015 to 2026.

This study examines the statistical association between forest cover reduction and SWL depth. The study is strictly correlational and does not establish direct physical causality. Through correlation analysis of secondary environmental datasets, the researchers evaluated whether measurable relationships exist between forest cover conditions and SWL depth variability. Forest cover is treated as an environmental variable that may be associated with groundwater conditions based on literature-supported hydrological relationships.

The study also references the findings of Ding et al. (2022) as conceptual support for forest–hydrology relationships. Their study reported that groundwater flow and interflow components tend to increase with higher forest cover. However, these findings are used only as theoretical support and are not treated as direct evidence for the conditions observed in Laur, Nueva Ecija.

A. Research Design

This study employed a quantitative correlational research design to analyze the statistical relationship between forest cover loss and Static Water Level (SWL) depth within the Sierra Madre boundary of Laur, Nueva Ecija. The study adopted a single-case approach focusing on the association between upland forest cover conditions and groundwater level variations over a 12-year period.

The research design is strictly correlational. The study focuses only on identifying statistical associations between the variables and does not attempt to establish causal relationships. Interpretations related to hydrological processes are limited to literature-supported explanations and are not presented as direct findings of the study.

The researchers utilized existing official records as the primary source of data to ensure consistency and reliability. Data was obtained from the Municipal Environment and Natural Resources Office (MENRO) of Laur, Nueva Ecija.

To determine the strength and significance of the relationship between forest cover and SWL depth, the researchers used the Pearson Correlation Coefficient (r) at a significance level of α = 0.05. The Pearson correlation coefficient measures the strength and direction of a linear relationship between two variables on a scale ranging from -1 to +1. A value close to +1 indicates a strong positive relationship, a value close to -1 indicates a strong negative relationship, and a value near 0 indicates no linear relationship. This coefficient is calculated using the following formula:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Figure 2. Pearson Correlation Coefficient Formula

B. Data Source and Preparation

The researchers utilized secondary data obtained from the Municipal Environment and Natural Resources Office (MENRO) of Laur, Nueva Ecija. The dataset included annual records of forest cover area and Static Water Level (SWL) depth from 2015 to 2026.

Forest cover values were recorded in hectares (ha), while SWL measurements were recorded in meters (m). The unit was verified to ensure consistency in data interpretation and analysis.

Since the study did not involve primary data collection, no survey questionnaires or interview instruments were used. The researchers organized the raw environmental records into a structured dataset for statistical analysis.

The data were reviewed for completeness and consistency across the 12-year period. Annual SWL depth values were aligned with the corresponding forest cover records. No interpolation or estimation techniques were applied to the dataset.

C. Reliability

The reliability of the study is based on the consistency of the secondary data obtained from MENRO, a government agency that follows standardized environmental monitoring procedures. The use of the Pearson Correlation Coefficient also contributes to methodological reliability because it is a widely accepted statistical tool for measuring linear relationships between variables.

However, the reliability of the findings is limited by the relatively small sample size (n = 12 years) and the study's dependence on pre-recorded secondary data.

D. Validity

The study maintains content validity by focusing on variables commonly examined in environmental and hydrological research, specifically forest cover and Static Water Level (SWL) depth.

The use of actual environmental records strengthens the validity of the data because the measurements reflect observed conditions in Laur, Nueva Ecija. However, the study has limited internal validity because other factors that may influence groundwater conditions were not directly measured or controlled. These factors may include:

- rainfall variability
- groundwater extraction
- seasonal differences in measurement periods

Because of these limitations and the correlational design of the study, the findings are interpreted strictly as statistical associations and not as evidence of cause-and-effect relationships.

IV. RESULT AND DISCUSSION

This chapter presents the results and discussion of the study focusing on the relationship between changes in forest cover and Static Water Level (SWL) depth in Laur, Nueva Ecija from 2015 to 2026.

The year 2022 recorded the highest forest cover loss at 709 m², while 2024 recorded the deepest SWL depth at 91 m. These values show noticeable variations in both forest cover and groundwater conditions throughout the study period. To determine the relationship between the variables, Pearson correlation analysis was applied to the dataset.

Table 1. The Data of Static Water and Forest Cover Area Loss

MENRO of Laur, Nueva Ecija

YEAR	STATIC WATER LEVEL/DEPTH OF WELL (m)	FOREST COVER AREA LOSS (m^2)
2015	90	450
2016	80	446
2017	80	489
2018	70	497
2019	60	646
2020	90	428
2021	75	631
2022	70	709
2023	84	448
2024	91	431
2025	86	495
2026	73	677

The table presents data gathered from the Municipal Environment and Natural Resources Office (MENRO) of Laur, Nueva Ecija, including static water level depth and forest cover area loss within the Sierra Madre boundary of Laur.

Null Hypothesis (H_0): There is no significant correlation between changes in forest cover and Static Water Level (SWL) depth.

Alternative Hypothesis (H_a)**:** There is a significant correlation between changes in forest cover and Static Water Level (SWL) depth.

Table 2. The Data of the Research Table

X	Y
90	450
80	446
80	489
70	497
60	646
90	428
75	631
70	709
84	448
91	431
86	495
73	677

Table 3. The Result of the Data

Parameter	Value
Pearson correlation coefficient (r)	-0.7893
P-value	0.003868
Covariance	-779.0182
Sample size	12
Statistics	-3.8564

Table 3 shows that the analysis produced a p-value of 0.003868, which is lower than the significance level of 0.05. Therefore, the null hypothesis is rejected. This indicates that there is a statistically significant relationship between forest cover loss and SWL depth.

The Pearson correlation coefficient of -0.7893 indicates a strong negative correlation between the two variables. This means that forest cover loss and SWL depth generally move in opposite directions. Periods with higher forest cover loss tended to correspond with lower SWL depth values, while periods with lower forest cover loss were associated with deeper SWL conditions. Since SWL represents depth below ground surface, higher SWL values indicate deeper groundwater levels.

Forest cover loss in Laur fluctuated throughout the 2015–2026 period, with the highest recorded losses occurring in 2022 and 2026. These changes may reflect land-use activities and environmental pressures within the Sierra Madre boundary.

Similarly, SWL depth also varied over time, with the deepest groundwater condition recorded in 2024. Groundwater conditions may be influenced by several factors such as rainfall variation, groundwater extraction, and land-use change.

Although the study found a significant statistical relationship between the variables, the results should not be interpreted as proof that forest cover loss directly caused changes in groundwater depth. The study is limited to secondary data analysis and does not include direct measurements of groundwater recharge, infiltration, precipitation, or groundwater pumping.

V. SUMMARY, CONCLUSION, AND RECOMMENDATION

The final chapter summarizes the thorough analysis carried out during this case study. It summarizes the important discoveries and offers useful suggestions for additional study and real-world application.

A. Summary of Findings

This study examined the relationship between forest cover loss and Static Water Level (SWL) depth in the Municipality of Laur, Nueva Ecija using secondary data from 2015 to 2026. Pearson correlation analysis showed a strong negative correlation between the two variables ($r = -0.7893$) with a statistically significant p-value of 0.003868. Since the p-value is lower than the significance level of 0.05, the null hypothesis was rejected.

The results indicate that forest cover loss and SWL depth generally varied inversely during the study period. Higher forest cover loss was commonly associated with lower SWL depth values, while lower forest cover loss corresponded with deeper SWL conditions. However, the relationship identified in the study is statistical and should not be interpreted as direct causation.

The study also observed fluctuations in both variables across the years. The highest forest cover loss occurred in 2022 and 2026, while the deepest SWL depth was recorded in 2024. These variations suggest that groundwater conditions in Laur may be affected by several environmental factors beyond forest cover changes alone.

B. Conclusion

The study found a statistically significant relationship between forest cover loss and Static Water Level (SWL) depth in Laur, Nueva Ecija. The negative Pearson correlation coefficient indicates that the two variables generally move in opposite directions during the study period.

However, the findings are limited to correlation analysis using secondary MENRO data from 2015 to 2026 and do not establish a direct cause-and-effect relationship between forest cover changes and groundwater conditions. Other factors such as rainfall variability, groundwater extraction, and land-use practices may also influence SWL depth.

Overall, the study provides baseline information on forest cover and groundwater conditions in Laur, Nueva Ecija. The findings may help support future environmental monitoring, watershed management, and groundwater studies in the area.

C. Recommendations

Based on the findings of the study, forest conservation and monitoring activities in Laur, Nueva Ecija should continue to support watershed protection and groundwater management. Local government agencies, environmental institutions, and community stakeholders may strengthen reforestation programs, environmental awareness campaigns, and regular monitoring of forest cover and groundwater conditions.

Future researchers are encouraged to conduct studies that include additional variables such as rainfall, groundwater extraction, soil characteristics, and water quality to provide a more comprehensive analysis of groundwater conditions in the area. Using larger datasets and multivariable statistical methods may also help improve understanding of the factors affecting groundwater levels in Laur, Nueva Ecija.

ACKNOWLEDGEMENT
The researchers express their sincere gratitude to God Almighty for guidance and strength throughout the study. They extend their appreciation to NEUST College of Engineering for fostering a conducive academic environment. They also acknowledge the Municipal Environment and Natural Resources Office (MENRO) for providing essential data.

REFERENCES

1. Bawafi, H., Indra, T. L., Kusratmoko, E., & Damayanti, A. (2020). Spatial analysis of deforestation in water recharge area at the Toyoaning Sub-watershed as a drought mitigation effort. *IOP Conference Series: Earth and Environmental Science, 412*(1), Article 012013. https://iopscience.iop.org/article/10.1088/1755-1315/412/1/012013
2. Dida, J. J. V., Tiburan Jr, C. L., & Saizen, I. (2021). Assessment of forest disturbances and carbon stock in Pantabangan-Carranglan watershed, Philippines, using remote sensing. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 46, 147-152. https://doi.org/10.5194/isprs-archives-XLVI-4-W6-2021-147-2021
3. Eco, R., Rodolfo, K.S., Sulapas, J.J., Morales Rivera, A.M., Lagmay, A.M.F., Amelung, F. (2020). Disaster in slow motion: Widespread land subsidence in and around Metro Manila, Philippines Quantified by Insar Time-Series Analysis. *JSM Environmental Science & Ecology, 8(1): 1068*
4. Flores, D. N. (2025, November 12). *Sierra Madre losing 9,000 hectares of forest cover each year—Haribon.* Philstar.com. https://www.philstar.com/headlines/climate-and-environment/2025/11/12/2486728/sierra-madre-losing-9000-hectares-forest-cover-each-year-haribon
5. Gabriel, M. J. C., Israel, K. P., Ugat, B. Z., Hintural, W., & Baldonado, M. (2025). Analysis of the contemporary drivers of deforestation and forest degradation in Southern Sierra Madre Region, Philippines. *ScieEnggJ*, *18*, 2025. https://doi.org/10.54645/202518SupVJC-12
6. Global Forest Watch. (2024). *Laur, Aurora, Philippines: Deforestation rates & statistics*. https://www.globalforestwatch.org/dashboards/country/PHL/55/13/
7. Huang, H., Liu, J., Guillaumot, L., Chen, A., de Graaf, I., & Chen, D. (2025). Contrasting impacts of irrigation and deforestation on Lancang-Mekong River Basin hydrology. *Communications Earth & Environment*, *6*, Article 107. *https://doi.org/10.1038/s43247-025-02093-8*
8. Ilstedt, U., Tobella, A. B., Bazié, H. R., Bayala, J., Verbeeten, E., Nyberg, G., Sanou, J., Benegas, L., Murdiyarso, D., Laudon, H., Sheil, D., & Malmer, A. (2016). Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics. *Scientific Reports*, *6*, Article 21930. https://doi.org/10.1038/srep21930
9. Jago-on, K.A., Kaneko, S., Komatsu, S. (2021). Social and economic impacts of flooding and land subsidence in KAMANAVA, Metro Manila. *Philippine Journal of Social Development 3(2011), 109-131*, https://tuklas.up.edu.ph/Record/IPP-00000003451
10. *Mainstreaming disaster risk reduction and climate change adaptation in comprehensive development planning of the cities in Nueva Ecija in the Philippines.* (2021). *International Journal of Disaster Risk Science*, *12*(4), 585–601. https://link.springer.com/article/10.1007/s13753-021-00351-9
11. Mangunay, I. D. (2022). *Spatial analysis of groundwater recharge potential and assessment of river flow duration characteristics in Inabanga Watershed* [Master’s thesis, De La Salle Universi https://animorepository.dlsu.edu.ph/etdm_civ/22/
12. Manuel, A. I., & Velasco, M. (2021). Reforestation program in Pantabangan-Carranglan Watershed forest reserve: An assessment. *British Journal of Environmental Studies*, *1*(1), 1–11. https://al-kindipublishers.org/index.php/bjes/article/view/2423
13. Mapulanga, A. M., & Naito, H. (2019). Effect of deforestation on access to clean drinking water. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(17), 8249–8254. https://doi.org/10.1073/pnas.1814970116
14. Oliveira, P. T. S., Leite, M. B., Mattos, T., Nearing, M. A., Scott, R. L., Xavier, R. O., Matos, D. M., & Wendland, E. (2017). Groundwater recharge decreases with increased vegetation density in the Brazilian Cerrado. *Ecohydrology*, *10*(1), Article e1759. https://doi.org/10.1002/eco.1759
15. PCAARRD-DOST (2024). *Current state of watershed in the Philippines.* https://ispweb.pcaarrd.dost.gov.ph/current-state-of-watershed-in-the-philippines
16. Pulhin, F. B., Magpantay, A. T., Almarines, N. R., Predo, C. D., & Pulhin, J. M. (2024). Land cover change and carbon loss: A case study of the Pagsanjan-Lumban and Baroro watersheds in Luzon, Philippines. *SciEnggJ*, *17*, 268–280. https://doi.org/10.54645/202417SupLOF-25

17. Ranjan, S. P., Kazama, S., & Sawamoto, M. (2006). Effects of climate and land use changes on groundwater resources in coastal aquifers. *Journal of Environmental Management*, *80*(1), 25–35. https://doi.org/10.1016/j.jenvman.2005.08.008
18. Sandoval, J. A., & Tiburan, C. L. (2021). Identification of potential artificial groundwater recharge sites in Mount Makiling Forest Reserve, Philippines using GIS and analytical hierarchy process. *Philippine Journal of Science*, *150*(3c), 751–768. https://www.ukdr.uplb.edu.ph/journal-articles/751
19. Tañagras, J., Macuha, R., & Herrera, E. (2023). Impact evaluation of land use-land cover change on the hydrology of Salipit River Basin Cavite, Philippines. *GEOMATE Journal*, *25*(110), 140–147. https://doi.org/10.21660/2023.110.3852
20. Tumbaga, J. R. A. (2023). Assessment of land cover change around Minalungao National Park, Nueva Ecija. *Applied Ecology and Environmental Research*, *21*(4), 3591–3613. http://dx.doi.org/10.15666/aeer/2104_35913613