International Cartographic Association
Association Cartographique Internationale

Geospatial analysis of land use and cover changes in the Ilo-Moquegua watershed

Osmar Cuentas Toledo [a,b]*, Alberto Bacilio Quispe Cohaila [b], Aloísio Machado da Silva Filho [c]

[a] *Universidad Nacional de Moquegua, ocuentast@unam.edu.pe,*
[b] *Universidad Nacional Jorge Basadre Grohmann, abqcsama@yahoo.es,*
[c] *Universidade Estadual de Feira de Santana - aloisioestatistico@uefs.br,*

* Corresponding author

Keywords: Land Use Changes, Ilo-Moquegua Watershed, Geospatial Analysis, Neural Networks, Environmental Planning

Abstract:

This study focuses on the evaluation of the change in land use and cover in the Ilo-Moquegua watershed, located in the Moquegua department in Peru, over a period of 51 years, from 1972 to 2023. Aerial photographs and Landsat images were used, and geoprocessing was applied using a multilayer perceptron neural network and evaluated with ArcGIS and TerrSet software to carry out a comprehensive analysis of the dynamics of historical changes in land use and cover in the watershed. The results revealed significant impacts in six categories of change in land use and cover in the Ilo-Moquegua watershed: Agriculture, Water, High Andean wetlands, Urban Infrastructure, Mining, and Natural. The degradation of the high Andean wetlands cover is particularly concerning, with a reduction from 1638.55 hectares in 1972 to 1384.68 hectares in 2023. In addition, significant changes were observed in the categories of land that changed from natural to mining (5953 hectares), natural to agriculture (5369.25 hectares), and natural to urban infrastructure (2105 hectares) during the study period. This analysis has important implications for land management and environmental planning in the Ilo-Moquegua watershed. The findings underline the need to implement sustainable development strategies that address the degradation of high Andean wetlandss and properly manage land use in this region. Furthermore, it serves as a valuable resource for informed decision-making in the framework of the 2030 Agenda and the pursuit of environmental justice in Latin America.

Table 1
Cross-tabulation matrix of the images from 1972 and 2012 in hectares

Categories	2012						
1972	Urban Infrastructure	Mining	Agriculture	Wetland	Water	Natural	Total 1972
Urban Infrastructure	**232.19**	0.00	0.00	0.00	0.00	0.00	232.19
Mining	0.00	**1968.90**	0.00	0.00	0.00	0.00	1968.90
Agriculture	160.62	0.00	**4959.25**	0.00	0.00	0.00	5119.87
Wetland	0.00	0.00	0.00	**1547.50**	0.00	91.05	1638.55
Water	0.00	0.00	0.00	0.00	**565.52**	16.93	582.45
Natural	1134.54	1439.94	3944.42	0.00	33.71	**337435.84**	343988.45
Total 2012	1527.35	3408.84	8903.67	1547.50	599.23	337543.82	353530.41

https://doi.org/10.5194/ica-abs-7-26-2024

Table 2
Cross-tabulation matrix of the images from 2012 and 2023 in hectares

Categories 2012	2023						Total 2012
	Urban Infrastructure	Mining	Agriculture	Wetland	Water	Natural	
Urban Infrastructure	**1527.35**	0.00	0.00	0.00	0.00	0.00	1527.35
Mining	0.00	**3408.84**	0.00	0.00	0.00	0.00	3408.84
Agriculture	40.81	0.00	**8862.86**	0.00	0.00	0.00	8903.67
Wetland	0.00	0.00	0.00	**1384.68**	0.00	162.82	1547.50
Water	0.00	0.00	0.00	0.00	**599.23**	0.00	599.23
Natural	969.88	4513.40	1425.26	0.00	0.00	**330635.28**	337543.82
Total 2023	2538.04	7922.24	10288.12	1384.68	599.23	330798.10	353530.41

References

Ait El Haj, F., Ouadif, L., & Akhssas, A. (2023). Simulating and predicting future land-use/land cover trends using CA-Markov and LCM models. Case Studies in Chemical and Environmental Engineering, 7(January), 100342. https://doi.org/10.1016/j.cscee.2023.100342

Ambarwulan, W., Yulianto, F., Widiatmaka, W., Rahadiati, A., Tarigan, S. D., Firmansyah, I., & Hasibuan, M. A. S. (2023). Modelling land use/land cover projection using different scenarios in the Cisadane Watershed, Indonesia: Implication on deforestation and food security. Egyptian Journal of Remote Sensing and Space Science, 26(2), 273–283. https://doi.org/10.1016/j.ejrs.2023.04.002

Asori, M., & Adu, P. (2023). Modeling the impact of the future state of land use land cover change patterns on land surface temperatures beyond the frontiers of greater Kumasi: A coupled cellular automaton (CA) and Markov chains approaches. Remote Sensing Applications: Society and Environment, 29, 100908. https://doi.org/10.1016/j.rsase.2022.100908

Charizopoulos, N., Mourtzios, P., Psilovikos, T., Psilovikos, A., & Karamoutsou, L. (2019). Morphometric analysis of the drainage network of Samos Island (northern Aegean Sea): Insights into tectonic control and flood hazards. Comptes Rendus - Geoscience, 351(5), 375–383. https://doi.org/10.1016/j.crte.2019.03.001

Cuentas Toledo, O. (2017). ANÁLISE ESPAÇO TEMPORAL DA BACIA HIDROGRÁFICA DO ALTO DO RIO MOQUEGUA NO PERU. Universidade Estadual de Feira de Santana.

Cuentas Toledo, O. (2019). Análisis espacio temporal de cambios de uso y cobertura de la tierra en la ciudad de Moquegua y el pueblo de Samegua de 1955 y 2018 [Universidad José Carlos Mariátegui]. https://doi.org/10.22533/at.ed.3892126085

Değermenci, A. S. (2023). Spatio-temporal change analysis and prediction of land use and land cover changes using CA-ANN model. Environmental Monitoring and Assessment, 195(10), 1229. https://doi.org/10.1007/s10661-023-11848-9

Edosa, B. T., & Nagasa, M. D. (2024). Spatiotemporal assessment of land use land cover change, driving forces, and consequences using geospatial techniques: The case of Naqamte city and hinterland, western Ethiopia. Environmental Challenges, 14(December 2023), 100830. https://doi.org/10.1016/j.envc.2023.100830

Entahabu, H. H., Minale, A. S., & Birhane, E. (2023). Modeling and Predicting Land Use/Land Cover Change Using the Land Change Modeler in the Suluh River Basin, Northern Highlands of Ethiopia. Sustainability (Switzerland), 15(10), 21–25. https://doi.org/10.3390/su15108202

FAO, F. and A. O. of the U. N. (2021). Land use statistics and indicators Global, regional and country trends 1990-2019.

Frimpong, B. F., Koranteng, A., Atta-Darkwa, T., Junior, O. F., & Zawiła-Niedźwiecki, T. (2023). Land Cover Changes Utilising Landsat Satellite Imageries for the Kumasi Metropolis and Its Adjoining Municipalities in Ghana (1986–2022). Sensors, 23(5). https://doi.org/10.3390/s23052644

Jing, Q., He, J., Li, Y., Yang, X., Peng, Y., Wang, H., Yu, F., Wu, J., Gong, S., Che, H., & Zhang, X. (2024). Analysis of the spatiotemporal changes in global land cover from 2001 to 2020. Science of the Total Environment, 908(August 2023), 168354. https://doi.org/10.1016/j.scitotenv.2023.168354

Leta, M. K., Demissie, T. A., & Tränckner, J. (2021). Modeling and prediction of land use land cover change dynamics based on land change modeler (Lcm) in nashe watershed, upper blue nile basin, Ethiopia. Sustainability (Switzerland), 13(7). https://doi.org/10.3390/su13073740

Liu, W., Wu, J., Xu, F., Mu, D., & Zhang, P. (2024). Modeling the effects of land use/land cover changes on river runoff using SWAT models: A case study of the Danjiang River source area, China. Environmental Research, 242(126), 117810. https://doi.org/10.1016/j.envres.2023.117810

Mapbiomas Perú, M. (2023). Aspectos destacados del mapeo anual de la cobertura y uso del suelo en Perú de 1985 a 2022. https://peru.mapbiomas.org/wp-content/uploads/sites/14/2024/02/1_ES_FactSheet_Mapbiomas_Peru_2.0-1080x1080px.pdf

Mendoza-Ponce, A. V., Corona-Núñez, R. O., Kraxner, F., & Estrada, F. (2020). Spatial prioritization for biodiversity conservation in a megadiverse country. Anthropocene, 32. https://doi.org/10.1016/j.ancene.2020.100267

MIDAGRI, & INEI. (2023). Encuesta Nacional Agropecuaria 2022. 2215-552X, 235.

MINAM, M. del A. (2021). Informe nacional sobre el estado del ambiente 2014-2019.

MINAM, M. del A. (2023). Documento de Resultados del Inventario Nacional de Gases de Efecto Invernadero 2000-2019. https://infocarbono.minam.gob.pe/wp-content/uploads/2023/01/Informe-INGEI-2019-VF_2.pdf

Ocloo, M. D., Huang, X., Fan, M., & Ou, W. (2024). Study on the spatial changes in land use and landscape patterns and their effects on ecosystem services in Ghana, West Africa. Environmental Development, 49(59), 100947. https://doi.org/10.1016/j.envdev.2023.100947

ONU, O. de las N. U. (2023). Informe de los Objetivos de Desarrollo Sostenible 2023: Edición especial. https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023_Spanish.pdf

Oscar, M., Shoko, C., Dube, T., & Mazvimavi, D. (2024). Remote Sensing Applications: Society and Environment An analysis of the effects of changes in land use and land cover on runoff in the Luvuvhu catchment, South Africa. Remote Sensing Applications: Society and Environment, 33(August 2023), 101144. https://doi.org/10.1016/j.rsase.2024.101144

Shi, L., Fang, J., & Zhao, Y. (2023). Automatic shadow detection in high-resolution multispectral remote sensing images. Computers and Electrical Engineering, 105(December 2022), 108557. https://doi.org/10.1016/j.compeleceng.2022.108557

Shi, L., & Zhao, Y. feng. (2023). Urban feature shadow extraction based on high-resolution satellite remote sensing images. Alexandria Engineering Journal, 77, 443–460. https://doi.org/10.1016/j.aej.2023.06.046

Silva, J. R. I., Montenegro, A. A. de A., Farias, C. W. L. de A., Jardim, A. M. da R. F., Silva, T. G. F. da, & Montenegro, S. M. G. L. (2022). Morphometric characterization and land use of the Pajeú river basin in the Brazilian semi-arid region. Journal of South American Earth Sciences, 118, 103939. https://doi.org/10.1016/j.jsames.2022.103939

Sisay, G., Gesesse, B., Fürst, C., Kassie, M., & Kebede, B. (2023). Modeling of land use/land cover dynamics using artificial neural network and cellular automata Markov chain algorithms in Goang watershed, Ethiopia. Heliyon, 9(9), e20088. https://doi.org/10.1016/j.heliyon.2023.e20088

https://doi.org/10.5194/ica-abs-7-26-2024