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DAFTAR PUSTAKA

Abdikan, S., Sanli, F. B., Ustuner, M., & Calò, F. (2016). Land Cover Mapping Using Sentinel-1 SAR Data. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLI-B7*, 757–761. https://doi.org/10.5194/isprs-archives-XLI-B7-757-2016

Al-Ghussain, L. (2019). Global warming: review on driving forces and mitigation. *Environmental Progress & Sustainable Energy*, *38*(1), 13–21. https://doi.org/10.1002/ep.13041

Amuyou, U. A., Wang, Y., Ebuta, B. F., Iheaturu, C. J., & Antonarakis, A. S. (2022). Quantification of Above-Ground Biomass over the Cross-River State, Nigeria, Using Sentinel-2 Data. *Remote Sensing*, *14*(22), 5741. https://doi.org/10.3390/rs14225741

Arjasakusuma, S., Swahyu Kusuma, S., Rafif, R., Saringatin, S., & Wicaksono, P. (2020). Combination of Landsat 8 OLI and Sentinel-1 SAR Time-Series Data for Mapping Paddy Fields in Parts of West and Central Java Provinces, Indonesia. *ISPRS International Journal of Geo-Information*, *9*(11), 663. https://doi.org/10.3390/ijgi9110663

Aronoff, S. (2005). *Remote Sensing for GIS Managers*. ESRI Press.

Avitabile, V., Herold, M., Heuvelink, G. B. M., Lewis, S. L., Phillips, O. L., Asner, G. P., Armston, J., Ashton, P. S., Banin, L., Bayol, N., Berry, N. J., Boeckx, P., de Jong, B. H. J., DeVries, B., Girardin, C. A. J., Kearsley, E., Lindsell, J. A., Lopez-Gonzalez, G., Lucas, R., … Willcock, S. (2016). An integrated pan-tropical biomass map using multiple reference datasets. *Global Change Biology*, *22*(4), 1406–1420. https://doi.org/10.1111/gcb.13139

Balzter, H. (2001). Forest mapping and monitoring with interferometric synthetic aperture radar (InSAR). *Progress in Physical Geography*, *25*(2), 159–177. https://doi.org/10.1191/030913301666986397

Bayanuddin, A. A., & Anna, A. N. (2016). *Pendugaan Cadangan Karbon Di Atas Permukaan Pada Hutan Rakyat Dengan Memanfaatkan Data Synthetic Aperture Radar Sentinel-1 (Studi Kasus Di Kabupaten Sukoharjo)*. Universitas Muhammadiyah Surakarta.

Bhatnagar, S., Gill, L., Regan, S., Naughton, O., Johnston, P., Waldren, S., & Ghosh, B. (2020). MAPPING VEGETATION COMMUNITIES INSIDE WETLANDS USING SENTINEL-2 IMAGERY IN IRELAND. *International Journal of Applied Earth Observation and Geoinformation*, *88*, 102083. https://doi.org/10.1016/j.jag.2020.102083

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Boisvenue, C., & White, J. (2019). Information Needs of Next-Generation Forest Carbon Models: Opportunities for Remote Sensing Science. *Remote Sensing*, *11*(4), 463. https://doi.org/10.3390/rs11040463

Braaten, J. D., Cohen, W. B., & Yang, Z. (2015). Automated cloud and cloud shadow identification in Landsat MSS imagery for temperate ecosystems. *Remote Sensing of Environment*, *169*, 128–138. https://doi.org/10.1016/j.rse.2015.08.006

Brown, S. (1997). *Estimating Biomass change of tropical forest a primer* (Vol. 134). Food & Agriculture Org.

Castillo, J. A. A., Apan, A. A., Maraseni, T. N., & Salmo, S. G. (2017a). Estimation and mapping of above-ground biomass of mangrove forests and their replacement land uses in the Philippines using Sentinel imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*, *134*, 70–85. https://doi.org/10.1016/j.isprsjprs.2017.10.016

Castillo, J. A. A., Apan, A. A., Maraseni, T. N., & Salmo, S. G. (2017b). Estimation and mapping of above-ground biomass of mangrove forests and their replacement land uses in the Philippines using Sentinel imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*, *134*, 70–85. https://doi.org/10.1016/j.isprsjprs.2017.10.016

Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., Duque, A., Eid, T., Fearnside, P. M., Goodman, R. C., Henry, M., Martínez-Yrízar, A., Mugasha, W. A., Muller-Landau, H. C., Mencuccini, M., Nelson, B. W., Ngomanda, A., Nogueira, E. M., Ortiz-Malavassi, E., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*(10), 3177–3190. https://doi.org/10.1111/gcb.12629

Chayaporn, P., Sasaki, N., Venkatappa, M., & Abe, I. (2021). Assessment of the overall carbon storage in a teak plantation in Kanchanaburi province, Thailand – Implications for carbon-based incentives. *Cleaner Environmental Systems*, *2*, 100023. https://doi.org/10.1016/j.cesys.2021.100023

Chen, Z., Sun, Z., Zhang, H., Zhang, H., & Qiu, H. (2023a). Aboveground Forest Biomass Estimation Using Tent Mapping Atom Search Optimized Backpropagation Neural Network with Landsat 8 and Sentinel-1A Data. *Remote Sensing*, *15*(24), 5653. https://doi.org/10.3390/rs15245653

Chen, Z., Sun, Z., Zhang, H., Zhang, H., & Qiu, H. (2023b). Aboveground Forest Biomass Estimation Using Tent Mapping Atom Search Optimized Backpropagation Neural Network with Landsat 8 and Sentinel-1A Data. *Remote Sensing*, *15*(24), 5653. https://doi.org/10.3390/rs15245653

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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Clevers, J. G. P. W., & Gitelson, A. A. (2013). Remote estimation of crop and grass chlorophyll and nitrogen content using red-edge bands on Sentinel-2 and -3. *International Journal of Applied Earth Observation and Geoinformation*, *23*, 344–351. https://doi.org/10.1016/j.jag.2012.10.008

Cohen, L. , Manion, L. , & Morrison, K. (2007). *Research Method in Education (6 th Edition)*. Routllege Falmer.

Congalton, R. G., & Green, K. (2008). *Assessing the Accuracy of Remotely Sensed Data*. CRC Press. https://doi.org/10.1201/9781420055139

Corbane, C., Politis, P., Kempeneers, P., Simonetti, D., Soille, P., Burger, A., Pesaresi, M., Sabo, F., Syrris, V., & Kemper, T. (2020). A global cloud free pixel- based image composite from Sentinel-2 data. *Data in Brief*, *31*, 105737. https://doi.org/10.1016/j.dib.2020.105737

Damanik, Y. V. (2018). *Penggunaan Citra Radar Sentinel-1 Untuk Identifikasi Tutupan Lahan di Kabupaten Pakpak Bharat.* . Universitas Sumatera .

Danoedoro, P. (2012). *Pengantar penginderaan jauh digital*. Penerbit Andi.

David, R. M., Rosser, N. J., & Donoghue, D. N. M. (2022). Improving above ground biomass estimates of Southern Africa dryland forests by combining Sentinel-1 SAR and Sentinel-2 multispectral imagery. *Remote Sensing of Environment*, *282*. https://doi.org/10.1016/j.rse.2022.113232

Degenhardt, F., Seifert, S., & Szymczak, S. (2019). Evaluation of variable selection methods for random forests and omics data sets. *Briefings in Bioinformatics*, *20*(2), 492–503. https://doi.org/10.1093/bib/bbx124

Delegido, J., Verrelst, J., Alonso, L., & Moreno, J. (2011). Evaluation of Sentinel-2 Red-Edge Bands for Empirical Estimation of Green LAI and Chlorophyll Content. *Sensors*, *11*(7), 7063–7081. https://doi.org/10.3390/s110707063

Dewantoro, B. E. B., & Jatmiko, R. H. (2021). Perbandingan Algoritma Speckle Filtering Pada Citra Synthetic Aperture Radar Untuk Estimasi Stok Karbon Vegetasi Tegakan Ruang Terbuka Hijau (Studi Kasus: Kecamatan Sungai Pinang , Kota Samarinda)). *Seminar Nasional Geomatika*, 35. https://doi.org/10.24895/SNG.2020.0-0.1118

Dong, P., Jing, C., Wang, G., Shao, Y., & Gao, Y. (2024). The Estimation of Grassland Aboveground Biomass and Analysis of Its Response to Climatic Factors Using a Random Forest Algorithm in Xinjiang, China. *Plants*, *13*(4), 548. https://doi.org/10.3390/plants13040548

Drusch, M., Del Bello, U., Carlier, S., Colin, O., Fernandez, V., Gascon, F., Hoersch, B., Isola, C., Laberinti, P., Martimort, P., Meygret, A., Spoto, F., Sy, O., Marchese, F., & Bargellini, P. (2012). Sentinel-2: ESA's Optical High-

UNIVERSITAS
GADJAH MADA
**Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Resolution Mission for GMES Operational Services. *Remote Sensing of Environment*, *120*, 25–36. https://doi.org/10.1016/j.rse.2011.11.026

ESA. (2014). *Overview of Sentinel-1 Mission.* https://sentiwiki.copernicus.eu/web/s1-mission

ESA. (2022). *Mission ends for Copernicus Sentinel-1B satellite.* https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-1/Mission_ends_for_Copernicus_Sentinel-1B_satellite

ESA. (2024a). *Copernicus Programme*. https://sentiwiki.copernicus.eu/web/copernicus-programme

ESA. (2024b). *Overview of Sentinel-2 Mission.* https://sentiwiki.copernicus.eu/web/s2-mission

European Space Agency. (2025). *S2 Products*. https://sentiwiki.copernicus.eu/web/s2-products

Filipponi, F. (2019). Sentinel-1 GRD Preprocessing Workflow. *3rd International Electronic Conference on Remote Sensing*, 11. https://doi.org/10.3390/ECRS-3-06201

Fischer, R., Ensslin, A., Rutten, G., Fischer, M., Schellenberger Costa, D., Kleyer, M., Hemp, A., Paulick, S., & Huth, A. (2015). Simulating Carbon Stocks and Fluxes of an African Tropical Montane Forest with an Individual-Based Forest Model. *PLOS ONE*, *10*(4), e0123300. https://doi.org/10.1371/journal.pone.0123300

Frampton, W. J., Dash, J., Watmough, G., & Milton, E. J. (2013). Evaluating the capabilities of Sentinel-2 for quantitative estimation of biophysical variables in vegetation. *ISPRS Journal of Photogrammetry and Remote Sensing*, *82*, 83–92. https://doi.org/10.1016/j.isprsjprs.2013.04.007

Gao, Y., Lu, D., Li, G., Wang, G., Chen, Q., Liu, L., & Li, D. (2018). Comparative Analysis of Modeling Algorithms for Forest Aboveground Biomass Estimation in a Subtropical Region. *Remote Sensing*, *10*(4), 627. https://doi.org/10.3390/rs10040627

Gascon, F., Bouzinac, C., Thépaut, O., Jung, M., Francesconi, B., Louis, J., Lonjou, V., Lafrance, B., Massera, S., Gaudel-Vacaresse, A., Languille, F., Alhammoud, B., Viallefont, F., Pflug, B., Bieniarz, J., Clerc, S., Pessiot, L., Trémas, T., Cadau, E., … Fernandez, V. (2017). Copernicus Sentinel-2A Calibration and Products Validation Status. *Remote Sensing*, *9*(6), 584. https://doi.org/10.3390/rs9060584

Georgopoulos, N., Sotiropoulos, C., Stefanidou, A., & Gitas, I. Z. (2022). Total Stem Biomass Estimation Using Sentinel-1 and -2 Data in a Dense Coniferous

UNIVERSITAS
GADJAH MADA
**Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Forest of Complex Structure and Terrain. *Forests*, *13*(12), 2157. https://doi.org/10.3390/f13122157

Ginting, T., & Prayogo, C. (2018). Pendugaan cadangan karbon hutan jati (Tectona grandis Linn. F) dengan berbagai persamaan alometrik pada berbagai kelas umur jati. *Jurnal Tanah Dan Sumberdaya Lahan*, *5*(2), 1019–1026.

Gitelson, A. A., Kaufman, Y. J., & Merzlyak, M. N. (1996). Use of a green channel in remote sensing of global vegetation from EOS-MODIS. *Remote Sensing of Environment*, *58*(3), 289–298. https://doi.org/10.1016/S0034-4257(96)00072-7

Goetz, S. J., Baccini, A., Laporte, N. T., Johns, T., Walker, W., Kellndorfer, J., Houghton, R. A., & Sun, M. (2009). Mapping and monitoring carbon stocks with satellite observations: a comparison of methods. *Carbon Balance and Management*, *4*(1), 2. https://doi.org/10.1186/1750-0680-4-2

Hairiah, K., & Rahayu, S. (2007). *Pengukuran 'karbon tersimpan' di berbagai macam penggunaan lahan*. . World Agroforestry Centre - ICRAF, SEA Regional Office, University of Brawijaya, Unibraw, Indonesia.

Hakim, M. A., Kamal, M., & Arjasakusuma, S. (2022). Mapping Mangrove Surface Carbon Stocks Using Multisensor Imagery In Clungup Mangrove Conservation (CMC) Malang Regency. *JURNAL GEOGRAFI*, *14*(2), 192. https://doi.org/10.24114/jg.v14i2.33575

Hansen, J. N., Mitchard, E. T. A., & King, S. (2020). Assessing Forest/Non-Forest Separability Using Sentinel-1 C-Band Synthetic Aperture Radar. *Remote Sensing*, *12*(11), 1899. https://doi.org/10.3390/rs12111899

Hanung, S. N. (2016). Estimasi Nilai Dan Korelasi Biomassa Terhadap Nilai NDVI Berbasis Metode Polarimetrik SAR Pada Citra QUAD-POL Alos Palsar Tahun 2007. *Jurnal Geodesi Undip*, *5*(1).

Hardianto, J. L., & Nurgiantoro, K. N. (2021). Perbandingan Metode Indeks Vegetasi NDVI, SAVI dan EVI Terkoreksi Atmoafer iCOR. *Jurnal Geografi Aplikasi Dan Teknologi*, *5*(1), 53–62.

Huang, X., Ziniti, B., Torbick, N., & Ducey, M. J. (2018). Assessment of Forest above Ground Biomass Estimation Using Multi-Temporal C-band Sentinel-1 and Polarimetric L-band PALSAR-2 Data. *Remote Sensing*, *10*(9), 1424. https://doi.org/10.3390/rs10091424

Huete, A., Didan, K., van Leeuwen, W., Miura, T., & Glenn, E. (2010). *MODIS Vegetation Indices* (pp. 579–602). https://doi.org/10.1007/978-1-4419-6749-7_26

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Huete, A. R. (1988a). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, *25*(3), 295–309. https://doi.org/10.1016/0034-4257(88)90106-X

Huete, A. R. (1988b). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, *25*(3), 295–309. https://doi.org/10.1016/0034-4257(88)90106-X

Husna, V. N. (2019). Estimasi Cadangan Karbon Biomassa di Atas Permukaan pada Tegakan Mangrove Menggunakan Pengindraan Jauh di Tongke-Tongke, Sulawesi Selatan. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, *9*(2), 456–466. https://doi.org/10.29244/jpsl.9.2.456-466

Jensen, J. R. (2015). *Introductory Digital Image Processing a Remote Sensing Perspective*. Person Education.

Jiang, F., Deng, M., Tang, J., Fu, L., & Sun, H. (2022). Integrating spaceborne LiDAR and Sentinel-2 images to estimate forest aboveground biomass in Northern China. *Carbon Balance and Management*, *17*(1), 12. https://doi.org/10.1186/s13021-022-00212-y

Kamal, M., Kanekaputra, T., Hermayani, R., & Utari, D. (2019). Pengaruh Distribusi Spasial Sampel Pemodelan Terhadap Akurasi Estimasi Leaf Area Index (LAI) Mangrove. *Urnal Penginderaan Jauh Dan Pengolahan Data Citra Digital*, *17*(2). https://doi.org/10.30536/j.pjpdcd.2019.v16.a3069

Kanmegne Tamga, D., Latifi, H., Ullmann, T., Baumhauer, R., Bayala, J., & Thiel, M. (2022). Estimation of Aboveground Biomass in Agroforestry Systems over Three Climatic Regions in West Africa Using Sentinel-1, Sentinel-2, ALOS, and GEDI Data. *Sensors*, *23*(1), 349. https://doi.org/10.3390/s23010349

Khan, K., Khan, S. N., Ali, A., Khokhar, M. F., & Khan, J. A. (2025). Estimating Aboveground Biomass and Carbon Sequestration in Afforestation Areas Using Optical/SAR Data Fusion and Machine Learning. *Remote Sensing*, *17*(5), 934. https://doi.org/10.3390/rs17050934

Kiran Dasari, & L.Anjaneyulu. (2017). Importance of Speckle Filter Window Size and its Impacton Speckle Reduction in SAR Images. *International Journal of Advances in Microwave Technology (IJAMT)* , *2*(2).

Krisnawati, H., Adinugroho, W. C., & Imanuddin, R. (2012). *Monograf model-model alometrik untuk pendugaan biomassa pohon pada berbagai tipe ekosistem hutan di Indonesia.* Badan Penelitian dan Pengembangan Kehutanan.

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Kumar, L., & Mutanga, O. (2017). Remote Sensing of Above-Ground Biomass. *Remote Sensing*, *9*(9), 935. https://doi.org/10.3390/rs9090935

Lan, X., Tans, P., & K.W. Thoning. (2024). *Trends in globally-averaged CO2 determined from NOAA Global Monitoring Laboratory measurements*. https://doi.org/https://doi.org/10.15138/9N0H-ZH07

Laurin, G. V., Balling, J., Corona, P., Mattioli, W., Papale, D., Puletti, N., Rizzo, M., Truckenbrodt, J., & Urban, M. (2018). Above-ground biomass prediction by Sentinel-1 multitemporal data in central Italy with integration of ALOS2 and Sentinel-2 data. *Journal of Applied Remote Sensing*, *12*(01), 1. https://doi.org/10.1117/1.JRS.12.016008

Lee, J. S., Jurkevich, L., Dewaele, P., Wambacq, P., & Oosterlinck, A. (1994). Speckle filtering of synthetic aperture radar images: A review. *Remote Sensing Reviews*, *8*(4), 313–340. https://doi.org/10.1080/02757259409532206

Li, C., Zhou, L., & Xu, W. (2021). Estimating Aboveground Biomass Using Sentinel-2 MSI Data and Ensemble Algorithms for Grassland in the Shengjin Lake Wetland, China. *Remote Sensing*, *13*(8), 1595. https://doi.org/10.3390/rs13081595

Li, Y., Li, M., Li, C., & Liu, Z. (2020). Forest aboveground biomass estimation using Landsat 8 and Sentinel-1A data with machine learning algorithms. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-67024-3

Li, Z., Bi, S., Hao, S., & Cui, Y. (2022). Aboveground biomass estimation in forests with random forest and Monte Carlo-based uncertainty analysis. *Ecological Indicators*, *142*, 109246. https://doi.org/10.1016/j.ecolind.2022.109246

Lillesand, T. M., & Kiefer, R. W. (1990). *Penginderaan dan Interpretasi Citra* (P. S. H. dan S. (Diterjemahkan oleh Dulbahri, Ed.). Gadjah Mada University Press.

Liu, Y., Gong, W., Xing, Y., Hu, X., & Gong, J. (2019). Estimation of the forest stand mean height and aboveground biomass in Northeast China using SAR Sentinel-1B, multispectral Sentinel-2A, and DEM imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*, *151*, 277–289. https://doi.org/10.1016/j.isprsjprs.2019.03.016

Lu, D. (2006). The potential and challenge of remote sensing-based biomass estimation. *International Journal of Remote Sensing*, *27*(7), 1297–1328. https://doi.org/10.1080/01431160500486732

Lucas, R., Accad, A., Randall, L., Bunting, P., & Armston, J. (2008). Assessing Human Impacts on Australian Forests through Integration of Remote Sensing

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Data. In *Patterns and Processes in Forest Landscapes* (pp. 213–239). Springer Netherlands. https://doi.org/10.1007/978-1-4020-8504-8_13

M. Venkataramanan, & Smitha. (2011). Causes and effects of global warming. *Indian Journal of Science and Technology*, *4*(3), 226–229. https://doi.org/10.17485/ijst/2011/v4i3/29971

Ma, T., Zhang, C., Ji, L., Zuo, Z., Beckline, M., Hu, Y., Li, X., & Xiao, X. (2024). Development of forest aboveground biomass estimation, its problems and future solutions: A review. *Ecological Indicators*, *159*, 111653. https://doi.org/10.1016/j.ecolind.2024.111653

Machali, I. (2021). *Metode Penelitian Kuantitatif Panduan Praktis Merencanakan, Melaksanakan dan Analisis dalam Penelitian Kuantitatif* (A. Q. Habib, Ed.). Fakultas Ilmu Tarbiyah dan Keguruan Universitas Islam Negeri (UIN) Sunan Kalijaga Yogyakarta .

Malhi, R. K. M., Anand, A., Srivastava, P. K., Chaudhary, S. K., Pandey, M. K., Behera, M. D., Kumar, A., Singh, P., & Sandhya Kiran, G. (2022). Synergistic evaluation of Sentinel 1 and 2 for biomass estimation in a tropical forest of India. *Advances in Space Research*, *69*(4), 1752–1767. https://doi.org/10.1016/j.asr.2021.03.035

Mansourpour, M., Rajabi, M. A., & Blais, J. A. R. (2006). *Effects And Perormance of Speckle Noise Reduction Filters On Active Radar and SAR Images.*

Maung, W. S., Tsuyuki, S., Hiroshima, T., & Htay, S. S. (2025). Assessing above ground biomass of Wunbaik Mangrove Forest in Myanmar using machine learning and remote sensing data. *Discover Conservation*, *2*(1), 8. https://doi.org/10.1007/s44353-025-00025-3

McCoy, R. M. (2005). *Field Methods in Remote Sensing*. The Guilfrod Press.

Meraner, A., Ebel, P., Zhu, X. X., & Schmitt, M. (2020). Cloud removal in Sentinel-2 imagery using a deep residual neural network and SAR-optical data fusion. *ISPRS Journal of Photogrammetry and Remote Sensing*, *166*, 333–346. https://doi.org/10.1016/j.isprsjprs.2020.05.013

Mjalli, F. S., Murshid, G., Al-Zakwani, S., & Hayyan, A. (2017). Monoethanolamine-based deep eutectic solvents, their synthesis and characterization. *Fluid Phase Equilibria*, *448*, 30–40. https://doi.org/10.1016/j.fluid.2017.03.008

Moreira, A., Prats-Iraola, P., Younis, M., Krieger, G., Hajnsek, I., & Papathanassiou, K. P. (2013). A tutorial on synthetic aperture radar. *IEEE Geoscience and Remote Sensing Magazine*, *1*(1), 6–43. https://doi.org/10.1109/MGRS.2013.2248301

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GADJAH MADA
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Muhe, S., & Argaw, M. (2022). Estimation of above-ground biomass in tropical afro-montane forest using Sentinel-2 derived indices. *Environmental Systems Research*, *11*(1), 5. https://doi.org/10.1186/s40068-022-00250-y

Mutanga, O., & Skidmore, A. K. (2004). Narrow band vegetation indices overcome the saturation problem in biomass estimation. *International Journal of Remote Sensing*, *25*(19), 3999–4014. https://doi.org/01431160310001654923

Nandy, S., Singh, R., Ghosh, S., Watham, T., Kushwaha, S. P. S., Kumar, A. S., & Dadhwal, V. K. (2017). Neural network-based modelling for forest biomass assessment. *Carbon Management*, *8*(4), 305–317. https://doi.org/10.1080/17583004.2017.1357402

Navarro, J. A., Algeet, N., Fernández-Landa, A., Esteban, J., Rodríguez-Noriega, P., & Guillén-Climent, M. L. (2019). Integration of UAV, Sentinel-1, and Sentinel-2 Data for Mangrove Plantation Aboveground Biomass Monitoring in Senegal. *Remote Sensing*, *11*(1), 77. https://doi.org/10.3390/rs11010077

Ningsih, E. P. (2024). Peran Hutan dalam Mitigasi Perubahan Iklim: Analisis Penyerapan Karbon oleh Hutan Hujan Tropis. *Journal of Horizon*, *1*(1), 1–5. https://doi.org/10.62872/5mqjxv79

Nuraini, N. F., Karang, I. W. G. A., & Putra, I. N. G. (2022). Estimasi Stok Karbon Di Atas Permukaan Menggunakan Citra Sentinel-1A di Hutan Mangrove Karang Sewu, Bali. *Journal of Marine Research and Technology*, *5*(1), 21. https://doi.org/10.24843/JMRT.2022.v05.i01.p05

Nuthammachot, N., Askar, A., Stratoulias, D., & Wicaksono, P. (2022). Combined use of Sentinel-1 and Sentinel-2 data for improving above-ground biomass estimation. *Geocarto International*, *37*(2), 366–376. https://doi.org/10.1080/10106049.2020.1726507

Pan, Y., Birdsey, R. A., Phillips, O. L., & Jackson, R. B. (2013). The Structure, Distribution, and Biomass of the World's Forests. *Annual Review of Ecology, Evolution, and Systematics*, *44*(1), 593–622. https://doi.org/10.1146/annurev-ecolsys-110512-135914

Pandit, S., Tsuyuki, S., & Dube, T. (2018). Landscape-Scale Aboveground Biomass Estimation in Buffer Zone Community Forests of Central Nepal: Coupling In Situ Measurements with Landsat 8 Satellite Data. *Remote Sensing*, *10*(11), 1848. https://doi.org/10.3390/rs10111848

Perhutani. (2024). *Divisi Regional Jawa Tengah*. https://www.perhutani.co.id/en/divisi-regional-jawa-tengah/

Pham, L. T. H., & Brabyn, L. (2017). Monitoring mangrove biomass change in Vietnam using SPOT images and an object-based approach combined with

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

machine learning algorithms. *ISPRS Journal of Photogrammetry and Remote Sensing*, *128*, 86–97. https://doi.org/10.1016/j.isprsjprs.2017.03.013

Pham, T. D., Le, N. N., Ha, N. T., Nguyen, L. V., Xia, J., Yokoya, N., To, T. T., Trinh, H. X., Kieu, L. Q., & Takeuchi, W. (2020a). Estimating mangrove above-ground biomass using extreme gradient boosting decision trees algorithm with fused sentinel-2 and ALOS-2 PALSAR-2 data in can Gio biosphere reserve, Vietnam. *Remote Sensing*, *12*(5). https://doi.org/10.3390/rs12050777

Pham, T. D., Le, N. N., Ha, N. T., Nguyen, L. V., Xia, J., Yokoya, N., To, T. T., Trinh, H. X., Kieu, L. Q., & Takeuchi, W. (2020b). Estimating Mangrove Above-Ground Biomass Using Extreme Gradient Boosting Decision Trees Algorithm with Fused Sentinel-2 and ALOS-2 PALSAR-2 Data in Can Gio Biosphere Reserve, Vietnam. *Remote Sensing*, *12*(5), 777. https://doi.org/10.3390/rs12050777

Pham, T. D., Yoshino, K., Le, N. N., & Bui, D. T. (2018). Estimating aboveground biomass of a mangrove plantation on the Northern coast of Vietnam using machine learning techniques with an integration of ALOS-2 PALSAR-2 and Sentinel-2A data. *International Journal of Remote Sensing*, *39*(22), 7761–7788. https://doi.org/10.1080/01431161.2018.1471544

Pham, T., Yokoya, N., Bui, D., Yoshino, K., & Friess, D. (2019). Remote Sensing Approaches for Monitoring Mangrove Species, Structure, and Biomass: Opportunities and Challenges. *Remote Sensing*, *11*(3), 230. https://doi.org/10.3390/rs11030230

Pratiwi, G., Sasmito, B., & Bashit, N. (2021). Analisis Prediksi Nilai Biomassa Atas Permukaan (Aboveground Biomass) Pohon Karet Menggunakan Citra Sentinel-1A Terhadap Usia Tegakan. *Elipsoida : Jurnal Geodesi Dan Geomatika*, *4*(01), 27–33. https://doi.org/10.14710/elipsoida.2021.11482

Purwanto, R. H., Rohman, R., Maryudi, A., Yuwono, T., Permadi, D. B., & Sanjaya, M. (2012). Potensi Biomasa dan Simpanan Karbon Jenis-jenis Tanaman Berkayu di Hutan Rakyat Desa Nglanggeran, Gunungkidul, Daerah Istimewa Yogyakarta. *Jurnal Ilmu Kehutanan*, *6*(2), 128. https://doi.org/10.22146/jik.5778

Purwitasari, H. (2011). *Model Persamaan Alometrik Biomassa dan Massa Karbon Pohon Akasia Mangium (Acacia mangium Willd.)* . Institut Pertanian Bogor.

Putri, N. A. G. (2022). *Perbandingan Akurasi Citra PlanetScope, Sentinel 2, dan Landsat 8 untuk Estimasi Stok Karbon Atas Permukaan Tegakan Jati (Tectona grandis) di BKPH Sampung dan BKPH Somoroto, Bagian Hutan Ponorogo Barat, KPH Madiun*. Universitas Gadjah Mada.

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
Atas Permukaan pada Hutan Jati di Sebagian Wilayah KPH Purwodadi
Imam Hanafi, Dr. Sigit Heru Murti BS, S.Si., M.Si. ; Dr. Retnadi Heru Jatmiko, M.Sc.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Rapiya, M., Ramoelo, A., & Truter, W. (2023). Seasonal evaluation and mapping of aboveground biomass in natural rangelands using Sentinel-1 and Sentinel-2 data. *Environmental Monitoring and Assessment*, *195*(12), 1544. https://doi.org/10.1007/s10661-023-12133-5

Richards, J. A. (2009). *Remote Sensing with Imaging Radar*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-02020-9

Ricke, A., Jaya, G., & Saleh, F. (2019). Perbandingan Model Transformasi Indeks Vegetasi Untuk Pemetaan Stok Karbon Di Kawasan Perkotaan. *Seminar Nasional Teknologi Terapan Berbasis Kearifan Lokal* , *2*(1).

Rima Hermayani. (2018). *Analisis Citra Sentinel-1A Untuk Estimasi Stok Karbon Di Atas Permukaan (Above Ground Carbon) Hutan Mangrove Pulau Kemujan Taman Nasional Karimun Jawa*. Universitas Gadjah Mada.

Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1974). Monitoring Vegetation Systems in the Great Plains with ERTS. *NASA SP*, *351*, 309–317.

Sasongko, D. A., Cita, K. D., Rusli, A. R., & Supriono, B. (2022). Kehilangan Karbon dan Oksigen pada Pemanenan Jati (Tectona grandis Linn. f) Unggul Nusantara di Kebun Percobaan Cogreg, Kecamatan Ciseeng, Kabupaten Bogor. *Jurnal Ilmu Pertanian Indonesia*, *28*(1), 72–77. https://doi.org/10.18343/jipi.28.1.72

Sayekti, R. T. (2023). *Estimasi Stok Karbon Hutan Jati (Tectonia grandis) Menggunakan Nilai Indeks Vegetasi Citra Sentinel-2 (Studi Kasus : Hutan Jati BKPH Kedungjati Kecamatan Kedungjati, Kabupaten Grobogan.* Universitas Diponegoro.

Sentinel-1 Team. (2013). *Sentinel-1 User Handbook*.

Septiana, B., Putra Wijaya, A., & Suprayogi, A. (2017). Analisis Perbadingan Hasil Orthorektifikasi Metode Range Dopples Terrain Correction dan Metode SAR Simulation Terrain Correction Menggunakan data SAR Sentinel -1. In *Jurnal Geodesi Undip Januari* (Vol. 6, Number 1). https://doi.org/10.14710/jgundip.2017.15363

Shaikh, M. S., Shariff, A. M., Bustam, M. A., & Murshid, G. (2015). Measurement and prediction of physical properties of aqueous sodium L-prolinate and piperazine as a solvent blend for CO2 removal. *Chemical Engineering Research and Design*, *102*, 378–388. https://doi.org/10.1016/j.cherd.2015.07.003

Shoko, C., & Mutanga, O. (2017). Examining the strength of the newly-launched Sentinel 2 MSI sensor in detecting and discriminating subtle differences

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

between C3 and C4 grass species. *ISPRS Journal of Photogrammetry and Remote Sensing*, *129*, 32–40. https://doi.org/10.1016/j.isprsjprs.2017.04.016

Sibanda, M., Mutanga, O., & Rouget, M. (2015). Examining the potential of Sentinel-2 MSI spectral resolution in quantifying above ground biomass across different fertilizer treatments. *ISPRS Journal of Photogrammetry and Remote Sensing*, *110*, 55–65. https://doi.org/10.1016/j.isprsjprs.2015.10.005

Simarmata, N., Nadzir, Z. A., & Sari, D. N. (2023). Analisis Perubahan Garis Pantai Menggunakan Metode Sentinel 1 Dual-Polarized Water Index (SDWI) Berbasis Data Multi Temporal pada Google Earth Engine. *Geomatika*, *29*(2), 107–120.

Small, D. (2011). Flattening Gamma: Radiometric Terrain Correction for SAR Imagery. *IEEE Transactions on Geoscience and Remote Sensing*, *49*(8), 3081–3093. https://doi.org/10.1109/TGRS.2011.2120616

Sommervold, O., Gazzea, M., & Arghandeh, R. (2023). A Survey on SAR and Optical Satellite Image Registration. *Remote Sensing*, *15*(3), 850. https://doi.org/10.3390/rs15030850

Stovall, A. E. L., Vorster, A. G., Anderson, R. S., Evangelista, P. H., & Shugart, H. H. (2017). Non-destructive aboveground biomass estimation of coniferous trees using terrestrial LiDAR. *Remote Sensing of Environment*, *200*, 31–42. https://doi.org/10.1016/j.rse.2017.08.013

Su, Y., Guo, Q., Xue, B., Hu, T., Alvarez, O., Tao, S., & Fang, J. (2016). Spatial distribution of forest aboveground biomass in China: Estimation through combination of spaceborne lidar, optical imagery, and forest inventory data. *Remote Sensing of Environment*, *173*, 187–199. https://doi.org/10.1016/j.rse.2015.12.002

Sutanto. (1987). *Penginderan Jauh:Jilid 2*. Gadjah Mada University Press.

Sutanto. (2013). *Metode Penelitian Penginderaan Jauh*. Ombak.

Sutaryo, D. (2009). *Penghitungan Biomassa, Sebuah Pengantar untuk Studi Karbon dan Perdagangan Karbon*. Wetlands International Indonesia Programme.

Tarigan, V. A., & Sasmito, B. (2019). Kajian Akurasi Penentuan Garis Pantai Menggunakan Citra Landsat 8 (Studi Kasus Kabupaten Lampung Timur). *Jurnal Geodesi Undip*, *8*(2), 328–337.

Tian, L., Wu, X., Tao, Y., Li, M., Qian, C., Liao, L., & Fu, W. (2023). Review of Remote Sensing-Based Methods for Forest Aboveground Biomass Estimation: Progress, Challenges, and Prospects. *Forests*, *14*(6), 1086. https://doi.org/10.3390/f14061086

UNIVERSITAS
GADJAH MADA
**Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Torres, R., Snoeij, P., Geudtner, D., Bibby, D., Davidson, M., Attema, E., Potin, P., Rommen, B., Floury, N., Brown, M., Traver, I. N., Deghaye, P., Duesmann, B., Rosich, B., Miranda, N., Bruno, C., L'Abbate, M., Croci, R., Pietropaolo, A., … Rostan, F. (2012). GMES Sentinel-1 mission. *Remote Sensing of Environment*, *120*, 9–24. https://doi.org/10.1016/j.rse.2011.05.028

Tran, T. V., Reef, R., & Zhu, X. (2022). A Review of Spectral Indices for Mangrove Remote Sensing. *Remote Sensing*, *14*(19), 4868. https://doi.org/10.3390/rs14194868

Truckenbrodt, J., Freemantle, T., Williams, C., Jones, T., Small, D., Dubois, C., Thiel, C., Rossi, C., Syriou, A., & Giuliani, G. (2019). Towards Sentinel-1 SAR Analysis-Ready Data: A Best Practices Assessment on Preparing Backscatter Data for the Cube. *Data*, *4*(3), 93. https://doi.org/10.3390/data4030093

Vafaei, S., Soosani, J., Adeli, K., Fadaei, H., Naghavi, H., Pham, T., & Tien Bui, D. (2018). Improving Accuracy Estimation of Forest Aboveground Biomass Based on Incorporation of ALOS-2 PALSAR-2 and Sentinel-2A Imagery and Machine Learning: A Case Study of the Hyrcanian Forest Area (Iran). *Remote Sensing*, *10*(2), 172. https://doi.org/10.3390/rs10020172

Vorster, A. G., Evangelista, P. H., Stovall, A. E. L., & Ex, S. (2020). Variability and uncertainty in forest biomass estimates from the tree to landscape scale: the role of allometric equations. *Carbon Balance and Management*, *15*(1), 8. https://doi.org/10.1186/s13021-020-00143-6

Wang, B., Jia, K., Liang, S., Xie, X., Wei, X., Zhao, X., Yao, Y., & Zhang, X. (2018). Assessment of Sentinel-2 MSI Spectral Band Reflectances for Estimating Fractional Vegetation Cover. *Remote Sensing*, *10*(12), 1927. https://doi.org/10.3390/rs10121927

Wang, C., Chen, J., Wu, J., Tang, Y., Shi, P., Black, T. A., & Zhu, K. (2017). A snow-free vegetation index for improved monitoring of vegetation spring green-up date in deciduous ecosystems. *Remote Sensing of Environment*, *196*, 1–12. https://doi.org/10.1016/j.rse.2017.04.031

Wang, C., Zhang, W., Ji, Y., Marino, A., Li, C., Wang, L., Zhao, H., & Wang, M. (2024). Estimation of Aboveground Biomass for Different Forest Types Using Data from Sentinel-1, Sentinel-2, ALOS PALSAR-2, and GEDI. *Forests*, *15*(1), 215. https://doi.org/10.3390/f15010215

Wang, Y., Hancock, S., Dong, W., Ji, Y., Zhao, H., & Wang, M. (2025). Analysis of the Application of Machine Learning Algorithms Based on Sentinel-1/2 and Landsat 8 OLI Data in Estimating Above-Ground Biomass of Subtropical Forests. *Forests*, *16*(4), 559. https://doi.org/10.3390/f16040559

UNIVERSITAS
GADJAH MADA
Perbandingan Citra Penginderaan Jauh Multisensor (Sentinel-1 dan Sentinel-2) untuk Pemetaan Biomassa
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Imam Hanafi, Dr. Sigit Heru Murti BS, S.Si., M.Si. ; Dr. Retnadi Heru Jatmiko, M.Sc.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Were, K., Bui, D. T., Dick, Ø. B., & Singh, B. R. (2015). A comparative assessment of support vector regression, artificial neural networks, and random forests for predicting and mapping soil organic carbon stocks across an Afromontane landscape. *Ecological Indicators*, *52*, 394–403. https://doi.org/10.1016/j.ecolind.2014.12.028

Yan, X., Feng, L., Sharma, R. P., Duan, G., Pang, L., Fu, L., & Guo, J. (2023). Evaluating Forest Site Quality Using the Biomass Potential Productivity Approach. *Forests*, *15*(1), 23. https://doi.org/10.3390/f15010023

Ying, X. (2019). An Overview of Overfitting and its Solutions. *Journal of Physics: Conference Series*, *1168*, 022022. https://doi.org/10.1088/1742-6596/1168/2/022022

Zhang, H., Tang, Z., Wang, B., Meng, B., Qin, Y., Sun, Y., Lv, Y., Zhang, J., & Yi, S. (2022). A non-destructive method for rapid acquisition of grassland aboveground biomass for satellite ground verification using UAV RGB images. *Global Ecology and Conservation*, *33*, e01999. https://doi.org/10.1016/j.gecco.2022.e01999

Zhang, X., Shen, H., Huang, T., Wu, Y., Guo, B., Liu, Z., Luo, H., Tang, J., Zhou, H., Wang, L., Xu, W., & Ou, G. (2024). Improved random forest algorithms for increasing the accuracy of forest aboveground biomass estimation using Sentinel-2 imagery. *Ecological Indicators*, *159*, 111752. https://doi.org/10.1016/j.ecolind.2024.111752