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DAFTAR PUSTAKA

Agustina, T.S. 2024. Pendampingan perumusan branding dukuh nglambur sebagai desa wisata di Kabupaten Kulon Progo. Prosiding Universitas Al-Irsyad National Conference Vol. 2, Cilacap.

Anderson, J.R. 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data. Vol. 964. US Government Printing Office, Washington D.C.

Anwar, D. dan B. Tripama. 2024. Analisis spasial kesesuaian lahan tanaman kopi robusta berdasarkan faktor curah hujan, elevasi dan topografi lahan (studi kasus: Kabupaten Jember). Callus: Journal of Agrotechnology Science 2(4): 39–48.

Aristizábal, N., Mora-Mena, S. E., Martínez-Salinas, A., Chain-Guadarrama, A., Castillo, D., Murillo, J. B., and Ricketts, T. H. 2025. Bee pollination affects coffee quality, yield, and trade-offs within them. Agriculture, Ecosystems and Environment, 377, 109258.

Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. Plant Physiology 24(1): 1–15.

Blum, A. 2010. Plant breeding for water-limited environments. Springer Science and Business Media. London.

Brady, N. C., and Weil, R. R. 2008. The nature and properties of soils (Vol. 13, pp. 662-710). Upper Saddle River, NJ: Prentice Hall.

Buckley, T. N. 2019. How do stomata respond to water status?. New Phytologist 224(1), 21-36.

Budiono, R., D. Sugarti, M. Nurzaman, T. Setiawati, T. Supriatun, dan A.Z. Mutaqin. 2022. Kerapatan stomata dan kadar klorofil tumbuhan Clausena excavata berdasarkan perbedaan intensitas cahaya. Prosiding SNPBS, Surakarta.

Bunn, C., Läderach, P., Ovalle Rivera, O., and Kirschke, D. 2015. A bitter cup: climate change profile of global production of Arabica and Robusta coffee. Climatic change 129(1), 89-101.

Chianucci, F., Puletti, N., Grotti, M., Bisaglia, C., Giannetti, F., Romano, E. and Tattoni, C. 2020. Influence of image pixel resolution on tutupan kanopi estimation in poplar plantations from field, aerial and satellite optical imagery. Annals of Silvicultural Research 46(1): 8–13.

Congalton, R.G. 1991. A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment 37(1): 35–46.

Corzo-Bacallao, J.A., Salas-Macías, C.A., Fonseca Rodriguez, O., Garcés-Fiallos, F.R., Alcívar-Muñoz, E.I. and Baque-Loor, H.F. 2023. Influence of tree shade on the growth and chlorophyll content of arabica coffee plants established in an agroforestry system at southern Manabí, Ecuador. Sarhad Journal of Agriculture 39(Special Issue 2): 37–47.

TUTUPAN KANOPI, KAPASITAS FISIOLOGIS DAN KOMPONEN HASIL KOPI ROBUSTA (Coffea canephora) AGROFORESTRI
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Coulston, J.W., G.G. Moisen, B.T. Wilson, M.V. Finco, W.B. Cohen, and C.K. Brewer. 2012. Modeling percent tree tutupan kanopi: a pilot study. Photogrammetric Engineering and Remote Sensing 78(7): 715–727.

DaMatta, F.M. and Ramalho, J.C. 2006. Impacts of drought and temperature stress on coffee physiology and production: a review. Brazilian Journal of Plant Physiology 18: 55–81.

DaMatta, F.M., Avila, R.T., Cardoso, A.A., Martins, S.C. and Ramalho, J.C. 2018. Physiological and agronomic performance of the coffee crop in the context of climate change and global warming: a review. Journal of Agricultural and Food Chemistry 66(21): 5264–5274.

DaMatta, F.M., Rahn, E., Läderach, P., Ghini, R. and Ramalho, J.C. 2019. Why could the coffee crop endure climate change and global warming to a greater extent than previously estimated? .Climatic Change 152(1): 167–178.

DaMatta, F.M., Ronchi, C.P., Maestri, M. and Barros, R.S. 2007. Ecophysiology of coffee growth and production. Brazilian Journal of Plant Physiology 19(4): 485–510.

De Castro, A.I., Shi, Y., Maja, J.M. and Peña, J.M. 2021. UAVs for vegetation monitoring: overview and recent scientific contributions. Remote Sensing 13(11): 2139.

Evizal, R. dan F.E. Prasmatiwi. 2022. Gejala produktivitas rendah dan pertanian degeneratif. Jurnal Agrotropika 21(2): 75–85.

Fitra, A. A. Y., Oakley, S., Prayogo, C., Sari, R. R., Saputra, D. D., Ishaq, R. M., and Suprayogo, D. (2024, February). Soil Water in Different Management Systems of Coffee-Pine Agroforestry and Its Relation to Coffee Bean Yields. In IOP Conference Series. Earth and Environmental Science (Vol. 1299, No. 1, p. 012009). IOP Publishing.

Foody, G.M. 2002. Status of land cover classification accuracy assessment. Remote Sensing of Environment 80(1): 185–201.

García-Martínez, H., H. Flores-Magdaleno, R. Ascencio-Hernández, A. Khalil-Gardezi, L. Tijerina-Chávez, O.R. Mancilla-Villa, and M.A. Vázquez-Peña. 2020. Corn grain yield estimation from vegetation indices, tutupan kanopi, plant density, and a neural network using multispectral and RGB images acquired with unmanned aerial vehicles. Agriculture 10(7): 277.

Grossiord, C., Buckley, T. N., Cernusak, L. A., Novick, K. A., Poulter, B., Siegwolf, R. T., and McDowell, N. G. 2020. Plant responses to rising vapor pressure deficit. New phytologist 226(6), 1550-1566.

Guo, W., Cherubini, P., Zhang, J., Li, M.H. and Qi, L. 2023. Leaf stomatal traits rather than anatomical traits regulate gross primary productivity of moso bamboo (*Phyllostachys edulis*) stands. Frontiers in Plant Science 14: 1117564.

TUTUPAN KANOPI, KAPASITAS FISIOLOGIS DAN KOMPONEN HASIL KOPI ROBUSTA (Coffea canephora) AGROFORESTRI
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H. Croft and J.M. Chen. 2018. Leaf Pigment Content. Comprehensive Remote Sensing, 117-142.

Hakim, L. 2021. Agroforestri kopi: mendorong taman hayati dan wisata kopi. Media Nusa Creative, Malang.

Hani, A., Indrajaya, Y., Suryanto, P. dan Budiadi. 2016. Dry land agroforestry practices in Menoreh Hills, Kulon Progo. AGRIVITA Journal of Agricultural Science 38(2): 193–203.

Hartiko, H.E., Del Rosario, J. and Carlos, J.T. 1982. Leaf and root nitrate reductase activities of coconut (*Cocos nucifera* L.) cultivars and hybrids. JIPI 3: 227–235.

John, A., K. Pradhan, M.J. Case, A.K. Ettinger, and J. Hille Ris Lambers. 2024. Forest tutupan kanopi affects microclimate buffering during an extreme heat event. Environmental Research Communications 6(9): 091015.

John, A., Olden, J.D., Oldfather, M.F., Kling, M.M. and Ackerly, D.D. 2024. Topography influences diurnal and seasonal microclimate fluctuations in hilly terrain environments of coastal California. PLoS One 19(3): e0300378.

Kath, J., Byrareddy, V. M., Craparo, A., Nguyen-Huy, T., Mushtaq, S., Cao, L., and Bossolasco, L. 2020. Not so robust: Robusta coffee production is highly sensitive to temperature. Global change biology 26(6), 3677-3688.

Kemal, R., M. Afanyalı, Z. Baharoğlu, İ. Eryavuz, M.E. Atik, and S.O. Atik. 2026. Pixel-based classification of olive trees using multi-spectral UAV images and vegetation indices. ISPRS Archives, 48: 195–200.

Keppel, G., S. Anderson, C. Williams, S. Kleindorfer, and C. O'Connell. 2017. Microhabitats and tutupan kanopi moderate high summer temperatures in a fragmented Mediterranean landscape. PLoS One 12(8): e0183106.

Korhonen, L., Korhonen, K. T., Rautiainen, M., and Stenberg, P. 2006. Estimation of forest canopy cover: a comparison of field measurement techniques.

Kusumayudha, S.B., Ciptahening, A.N., Purwanto, H.S., Kristanto, W.A.D. and Nugroho, N.E. 2020. Slope movement characteristic and models based on engineering-geological properties of the Menoreh Hills, Purworejo Regency, Central Java, Indonesia. AIP Conference Proceedings 2245(1): 070014.

Lal, R. 2020. Soil organic matter and water retention. Agronomy Journal 112(5): 3265–3277.

Lawson, T., and Vialet-Chabrand, S. 2019. Speedy stomata, photosynthesis and plant water use efficiency. New Phytologist 221(1), 93-98.

León-Burgos, A. F., Sáenz, J. R. R., Quinchua, L. C. I., Toro-Herrera, M. A., Unigarro, C. A., Osorio, V., and Balaguera-López, H. E. 2024. Increased fruit load influences vegetative growth, dry mass partitioning, and bean quality attributes in full-sun coffee cultivation. Frontiers in Sustainable Food Systems, 8, 1379207.

TUTUPAN KANOPI, KAPASITAS FISIOLOGIS DAN KOMPONEN HASIL KOPI ROBUSTA (Coffea canephora) AGROFORESTRI
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Li, Y., G. Deng, H. Zhao, B. Liu, C. Liu, W. Qian, and X. Qiao. 2026. A review of UAV remote sensing technology applications in common gramineous crops. Information Processing in Agriculture.

Lotz, S., Pandit, B.H., Schmidt, H.P. and Hölscher, D. 2026. Trade-off between yield and carbon storage in Nepali coffee agroforestry. Agroforestry Systems 100(1): 49.

Malik, A.Q., Boon, Y.C. and Zainal, N.B.H.Z. 2004. Measurements of solar radiation. Asian Journal of Energy and Environment 5(1): 1–17.

Marbun, T.P.F. 2024. Studi komparatif usahatani kopi arabika dan kopi robusta pola swadaya di Dusun Nglambur Desa Sidoharjo Kecamatan Samigaluh Kabupaten Kulon Progo. Disertasi Doktor. Politeknik LPP Yogyakarta.

Marita, L., M. Arief, N. Andriani, dan M.A. Wildan. 2021. Strategi peningkatan kesejahteraan petani Indonesia: review manajemen strategis. Agriekonomika 10(1): 1–18.

Maulani, R.D. dan D. Wahyuningsih. 2021. Analisis ekspor kopi Indonesia pada pasar internasional. Jurnal Pamator 14(1): 27–33.

Mawardhi, A.D. dan D. Setiadi. 2019. Strategi pemanfaatan lahan gambut melalui pengembangan agroforestri kopi liberika (*Coffea liberica*). Prosiding Seminar Nasional Lahan Suboptimal.

Max, A.C., Loram-Lourenço, L., Silva, F.G., de Souza, L.H.M., Dias, J.R.M., Espíndula, M.C. and Menezes-Silva, P.E. 2023. A bitter future for coffee production? Physiological traits associated with yield reveal high vulnerability to hydraulic failure in Coffea canephora. Plant, Cell and Environment 46(3): 764–779.

Middleby, K. B., Cheesman, A. W., and Cernusak, L. A. 2024. Impacts of elevated temperature and vapour pressure deficit on leaf gas exchange and plant growth across six tropical rainforest tree species. New Phytologist 243(2), 648-661.

Mohammed, T., and Worku, M. 2025. Pruning and fertilising effects on yield and yield components of arabica coffee in its centre of origin in southwest Ethiopia. The Journal of Agricultural Science 163(5), 493-502.

Moreira, S. L., Pires, C. V., Marcatti, G. E., Santos, R. H., Imbuzeiro, H. M., and Fernandes, R. B. 2018. Intercropping of coffee with the palm tree, macauba, can mitigate climate change effects. Agricultural and forest meteorology, 256, 379-390.

Murphy, M.C.R., Jordan, G.J. and Brodribb, T.J. 2014. Acclimation to humidity modifies the link between leaf size and the density of veins and stomata. Plant, Cell and Environment 37(1): 124–131.

Mursyid, H., Suryanto, P., Fadhilla, S., Silmia, B. dan Wibowo, F.A.C. 2025. Diversity and ecophysiological performance of coffee under dry-field and homegarden agroforestry in Yogyakarta. Jurnal Sylva Lestari 13(1): 75–89.

TUTUPAN KANOPI, KAPASITAS FISIOLOGIS DAN KOMPONEN HASIL KOPI ROBUSTA (Coffea canephora) AGROFORESTRI
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Niinemets, Ü. 2023. Variation in leaf photosynthetic capacity within plant canopies: optimization, structural, and physiological constraints and inefficiencies. Photosynthesis Research 158(2): 131–149.

Niinemets, Ü., T.F. Keenan, and L. Hallik. 2014. A worldwide analysis of within-canopy variations in leaf structural, chemical and physiological traits across plant functional types. New Phytologist 205(3): 973–993.

Pellant, M., P.L. Shaver, D.A. Pyke, J.E. Herrick, N. Lepak, G. Riegel, E. Kachergis, B.A. Newingham, D. Toledo, and F.E. Busby. 2020. Interpreting Indicators of Rangeland Health, Version 5. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver.

Permanasari, P. N., Wicaksono, K. P., Saitama, A., Kusuma, B. A., and Bamratama, M. R. 2024. Productivity of arabica coffee in Brawijaya University's Agroforestry. International Journal of Environment, Agriculture and Biotechnology 9(2), 137-142.

Pompelli, M.F., Pompelli, G.M., Cabrini, E.C. and Ventrella, M.C. 2012. Leaf anatomy, ultrastructure and plasticity of Coffea arabica L. in response to light and nitrogen availability. Biotemas 25(4): 13–28.

Poorter, H., Niinemets, Ü., Ntagkas, N., Siebenkäs, A., Mäenpää, M., Matsubara, S., and Pons, T. 2019. A meta-analysis of plant responses to light intensity for 70 traits ranging from molecules to whole plant performance. New Phytologist 223(3), 1073-1105.

Pratinda, W.N.A.S. dan R. Harta. 2021. Analisis kinerja ekspor subsektor perkebunan Indonesia dan pandemi Covid-19. Jurnal Ekonomi dan Kebijakan Pembangunan 10(2): 114–133.

Prayogo, C., Arfarita, N., Luthfiningsih, F., Fajrina, N., and Sholih, N. A. 2026. Soil respiration and microbial communities across different farming management of shaded coffee and pines on agroforestry system. Biodiversitas: Journal of Biological Diversity 27(2), 1.

Purwanto, E., Supriyadi, S., and Rahayu, M. 2020. Growth and yield performance of Siare clone robusta coffee at different altitudes. Journal of Physics: Conference Series, 1422, 012038.

Radjawane, I.M., J.D. Marco, D.D. Suryono, H.L. Salim, A. Tarya, S. Nurdjaman, and G. Napitupulu. 2025. Assessment of marine debris using UAV imagery in Cinta Coast, Indonesia. AACL Bioflux 18(2): 622–638.

Ramirez-Builes, V.H., Küsters, J., Thiele, E. and Lopez-Ruiz, J.C. 2024. Physiological and agronomical response of coffee to different nitrogen forms with and without water stress. Plants 13(10): 1387.

Randriani, E., Fidiyawati, E., Sulistiono, W., Sakiroh, S., Saefudin, S., Wardiana, E., and Avivi, S. 2026. Agromorphological traits associated with high yield potential in 21

TUTUPAN KANOPI, KAPASITAS FISIOLOGIS DAN KOMPONEN HASIL KOPI ROBUSTA (Coffea canephora) AGROFORESTRI
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Robusta coffee accessions from Indonesia. Chilean journal of agricultural research 86(2), 189-201.

Ratnawati, M.I., A. Fariyanti, dan A.D. Utami. 2024. Risiko produksi kopi arabika sistem agroforestri dan non agroforestri di Kabupaten Bandung. Prosiding Forum Agribisnis, Bogor.

Riastuti, A.D., S. Komarayanti, dan A.P. Utomo. 2021. Karakteristik morfologi biji kopi robusta (Coffea canephora) pascapanen di kawasan lereng Meru Betiri. Jurnal Ilmu Pendidikan 5(2): 1–13.

Ritung, S., K. Nugroho, A. Mulyani, dan E. Suryani. 2011. Petunjuk teknis evaluasi lahan untuk komoditas pertanian (Edisi Revisi). Badan Penelitian dan Pengembangan Pertanian, Bogor.

Saimun, M.S.R. and M.M. Rahman. 2025. A comprehensive review of tree cover mapping using satellite sensor data. Discover Geoscience 3(1): 90.

Sholikhah, U., D. Munandar, dan A. Pradana. 2015. Karakter fisiologis klon kopi robusta BP 358 pada jenis penaung yang berbeda. Agrovigor 8(1): 58–67.

Somarriba, E., S. Saj, L. Orozco-Aguilar, A. Somarriba, and B. Rapidel. 2024. Shade canopy density variables in cocoa and coffee agroforestry systems. Agroforestry Systems 98(3): 585–601.

Subandi, M. 2011. Budidaya tanaman perkebunan (bagian tanaman kopi). Gunung Djati Press, Bandung.

Suhendra, D. dan S. Evendi. 2020. Perubahan kondisi fisik buah kopi (*Coffea* sp.) setelah disimpan selama 1 bulan. Jurnal Agroplasma 7(2): 65–71.

Suherman, S.M. dan L. Asrul. 2016. Respon morfofisiologi, fenologi, dan produksi tanaman kopi terhadap berbagai naungan dalam sistem agroforestri di Kabupaten Enrekang. Sains dan Teknologi 16(2): 197–202.

Sunde, M.G., D.D. Diamond, L.F. Elliott, P. Hanberry, and D. True. 2020. Mapping high-resolution percentage tutupan kanopi using a multi-sensor approach. Remote Sensing of Environment, 242: 111748.

Teixeira, H. M., Bianchi, F. J., Cardoso, I. M., Tittonell, P., and Peña-Claros, M. 2021. Impact of agroecological management on plant diversity and soil-based ecosystem services in pasture and coffee systems in the Atlantic forest of Brazil. Agriculture, Ecosystems and Environment, 305, 107171.

Unigarro, C.A., Cayón Salinas, D.G., León-Burgos, A.F. and Flórez-Ramos, C.P. 2025. Flowering and fruiting of Coffea arabica L.: a comprehensive perspective from phenology. Plants 14(21): 3396.

Vaast, P., Angrand, J., Franck, N., Dauzat, J. and Génard, M. 2005. Fruit load and branch ring-barking affect carbon allocation and photosynthesis of leaf and fruit of Coffea arabica in the field. Tree Physiology 25(6): 753–760.

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Vasavi, S., Likhitha, A.L., Premchand, V.S. and Yasaswini, J. 2024. Object classification by effective segmentation of tree canopy using U-Net model. Journal of Advances in Information Technology 15(3): 422–434.

Wardana, R.R., T. Hakim, dan Sulardi. 2023. Budidaya tanaman kopi arabika. Dewangga Energi Internasional, Bekasi.

Wibowo, A. 2021. Karakter perakaran sejumlah varietas kopi arabika pada fase bibit di pesemaian. Agrotechnology Research Journal 5(1).

Zhang, J., Ge, J., Dayananda, B., and Li, J. 2022. Effect of light intensities on the photosynthesis, growth and physiological performances of two maple species. Frontiers in plant science, 13, 999026.

Zhang, S., X. Wang, H. Lin, and Z. Qiang. 2025. A review of the application of UAV multispectral remote sensing technology in precision agriculture. Smart Agricultural Technology: 101406.