

YEM ÜRETİMİNDE ÇEVRESEL FAKTÖRLER

BÖLÜM

17

DOI: 10.37609/akya.3801.c308

Şerife AKKEÇECİ¹

1. GİRİŞ

Günümüzde yem üretiminin çevresel etkilerinin kapsamlı analiz edilmesi, tarımsal sürdürülebilirlik açısından zorunlu hâle gelmiştir. Küresel nüfus artışıyla artan gıda talebi, tarım sistemlerinde köklü dönüşümleri beraberinde getirmiştir (1). Yem bitkileri, yalnızca hayvan beslenmesinde değil; doğal kaynakların korunması ve ekosistem dengesinin sağlanmasında da önemli rol oynamaktadır (2). Bu nedenle yem üretiminin çevresel boyutlarının değerlendirilmesi, sürdürülebilir tarım stratejileri açısından stratejik bir gerekliliktir (3). Yoğun tarımsal kullanım, toprak yapısını bozarak erozyon riskini artırırken (4); kimyasal gübre ve pestisitler, su kaynaklarının kirlenmesine neden olmaktadır (5-7). Ayrıca yem bitkilerinin yüksek su ihtiyacı, özellikle su kıtlığı yaşayan bölgelerde ciddi kaynak baskısı yaratmaktadır (8-10). Hayvancılık kaynaklı metan emisyonları ise iklim değişikliği açısından önemli bir tehdit oluşturmaktadır (11). Bu bağlamda, çevresel etkileri azaltmaya yönelik yeni yaklaşımların ve sürdürülebilir tarım modellerinin geliştirilmesi büyük önem taşımaktadır. Alternatif yem kaynaklarının kullanımı (12) ve yerel, organik üretim tekniklerinin teşviki, çevresel yükün azaltılmasına katkı sağlayabilir. Ayrıca yem üretimi ile hayvansal üretimin bütüncül bir yaklaşımla ele alınması, sektörel yeniliklerin teşvikine ve uzun vadeli çevresel sürdürülebilirliğe olanak tanıyacaktır (13). Bu çalışma, yem üretiminin çevresel etkilerini disiplinler arası bir bakışla inceleyerek tarım-çevre etkileşiminin daha iyi anlaşılmasına katkı sunmayı amaçlamaktadır.

¹ Dr. Öğr. Üyesi, Kahramanmaraş Sütçü İmam Üniversitesi, Göksun Meslek Yüksekokulu Bitkisel ve Hayvansal Üretim Bölümü, sakkececi@ksu.edu.tr, ORCID iD: 0000-0003-0283-3973

lemektedir. Özellikle bilgi temelli karar alma mekanizmalarının yaygınlaştırılması, politika ve uygulama arasında etkin bir köprü kurarak sürdürülebilirlik hedeflerinin gerçekleştirilmesinde stratejik bir rol üstlenmektedir. Geleceğe yönelik olarak, yem üretimi sistemlerinin dönüşümü ancak çiftçiler, araştırmacılar, politika yapıcılar, özel sektör ve tüketiciler başta olmak üzere tüm paydaşların aktif katılımı ile mümkündür. Bu çok aktörlü yapı içerisinde geliştirilecek kapsayıcı, dirençli ve çevresel olarak sorumlu stratejiler, yalnızca günümüzün çevresel problemlerine çözüm sunmakla kalmayacak; aynı zamanda gelecek kuşakların gıda güvencesi ve ekosistem hizmetlerine erişimi açısından da kritik bir güvence oluşturacaktır (21). Bu nedenle sürdürülebilir yem üretimi, gıda sistemlerinde dönüşümün temel eksenlerinden biri olarak ele alınmalı; multidisipliner, entegre ve uzun vadeli yaklaşımlarla desteklenmelidir.

KAYNAKLAR

1. FAO. Sustainable Agricultural Mechanization for Smallholders: Policy Briefs. Rome: Food and Agriculture Organization of the United Nations; 2020.
2. Henry M, Gasco L, Piccolo G, Fountoulaki E. Review on the use of insects in the diet of farmed fish: Past and future. *Animal Feed Science and Technology*. 2015;203:1–22. doi:10.1016/j.anifeedsci.2015.03.003.
3. Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. Agricultural sustainability and intensive production practices. *Nature*. 2002;418(6898):671–677. doi:10.1038/nature01014.
4. Lal R. Restoring soil quality to mitigate soil degradation. *Sustainability*. 2015;7(5):5875–5895. doi:10.3390/su7055875.
5. Briñez J, Yepes G, Hernandez D. Causes and effects of contamination of water sources due to excessive use of agrochemicals and pesticides: bibliometric analysis. *Water Policy*. 2024. doi:10.2166/wp.2024.107.
6. Makkar HPS, et al. State-of-the-art on use of insects as animal feed. *Animal Feed Science and Technology*. 2014;197:1–33. doi:10.1016/j.anifeedsci.2014.07.008.
7. Rad S, Ray A, Barghi S. Water Pollution and Agriculture Pesticide. *Clean Technologies*. 2022. doi:10.3390/cleantechnol4040066.
8. Baghdadi A, Golzardi F, Hashemi M. The use of alternative irrigation and cropping systems in forage production may alleviate the water scarcity in semiarid regions. *Journal of the Science of Food and Agriculture*. 2023. doi:10.1002/jsfa.12574.
9. Hussein M, Hailelassie A, Derseh M, et al. Enhancing irrigated forage crop production through water and nutrient management in the Ethiopian sub-humid highlands. *Frontiers in Sustainable Food Systems*. 2024. doi:10.3389/fsufs.2024.1373698.
10. Mekonnen MM, Hoekstra AY. A global assessment of the water footprint of farm animal products. *Ecosystems*. 2012;15(3):401–415. doi:10.1007/s10021-011-9517-8.
11. teinfeld H, Gerber P, Wassenaar T, et al. Livestock's long shadow: Environmental issues and options. FAO. Available from: <https://www.fao.org/3/a0701e/a0701e.pdf>.
12. Makkar HPS. Smart livestock feeding strategies for improving economic and environmental sustainability. *Animal Production Science*. 2016;56(8):1320–1328. doi:10.1071/AN15271.
13. Herrero M, Thornton PK, Gerber P, Reid RS. Livestock, livelihoods and the environment:

- Understanding the trade-offs. *Current Opinion in Environmental Sustainability*. 2013;6:109–115. doi:10.1016/j.cosust.2013.11.003.
14. Dittmann M, Leiber F. Effect size and land-requirements of plant-based feeding interventions to reduce methane emissions from cattle and sheep in European subalpine regions. *Animal Feed Science and Technology*. 2024. doi:10.1016/j.anifeedsci.2024.115884.
 15. Cabrera E, Mondragón Y, Vargas B, Pino A, Espinosa Z. Effects of Mountain Microorganisms on the Growth and Development of the Bean Crop (*Phaseolus Vulgaris* L.) in the Municipality of Caldono, Cauca, Colombia. *Land Degradation & Development*. 2025. doi:10.1002/ldr.5465.
 16. FAO. The future of food and agriculture – Drivers and triggers for transformation. Rome: Food and Agriculture Organization of the United Nations; 2021.
 17. Matson PA, Parton WJ, Power AG, Swift MJ. Agricultural intensification and ecosystem properties. *Science*. 1997;277(5325):504–509. doi:10.1126/science.277.5325.504.
 18. Zhang N, Wang M, Wang N. Precision agriculture—a worldwide overview. *Computers and Electronics in Agriculture*. 2002;36(2–3):113–132. doi:10.1016/S0168-1699(02)00096-0.
 19. Foley JA, et al. Solutions for a cultivated planet. *Nature*. 2011;478:337–342. doi:10.1038/nature10452.
 20. Gislón G, Ferrero F, Bava L, Borreani G, Prá A, Pacchioli M, et al. Forage systems and sustainability of milk production: Feed efficiency, environmental impacts and soil carbon stocks. *Journal of Cleaner Production*. 2020;260:121012. doi:10.1016/j.jclepro.2020.121012.
 21. Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JE, et al. Food security: The challenge of feeding 9 billion people. *Science*. 2010;327(5967):812–818. doi:10.1126/science.1185383.
 22. Garnett T, Appleby MC, Balmford A, et al. Sustainable intensification in agriculture: Premises and policies. *Science*. 2013;341(6141):33–34. doi:10.1126/science.1234485.
 23. Zhang Y, Wang P, Lu C, Jin T, Liu W. Impact of long-term fertilization on soil properties and microbial communities. *Applied Soil Ecology*. 2021;163:103912. doi:10.1016/j.apsoil.2021.103912.
 24. Nowak A, Majewska M, Marzec-Grządziel A, et al. Effect of long-term radish (*Raphanus sativus* var. *sativus*) monoculture practice on physiological variability of microorganisms in cultivated soil. *Journal of Environmental Management*. 2024;367:122007. doi:10.1016/j.jenvman.2024.122007.
 25. FAO. *Climate Smart Agriculture Sourcebook*. Rome: Food and Agriculture Organization of the United Nations; 2013.
 26. Lipper L, Thornton P, Campbell BM, et al. Climate-smart agriculture for food security. *Nature Climate Change*. 2014;4:1068–1072.
 27. IPCC. *Climate Change and Land – Special Report*. Intergovernmental Panel on Climate Change. 2019.
 28. Smith P, et al. Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification?. *Global Change Biology*. 2020.
 29. Reganold JP, Wachter JM. Organic agriculture in the twenty-first century. *Nature Plants*. 2016;2(2):15221. doi:10.1038/nplants.2015.221.
 30. Singh Y, Rakesh S, Singh B. Organic Farming for Residue-Free Production. *Journal of Experimental Agriculture International*. 2024. doi:10.9734/jeai/2024/v46i102978.
 31. Hazmi M, Suryaningrum D, Umarie I, Aniar M, Swasono H. Emerging Trends and Future Directions in Organic Agriculture and Environmentally-friendly Farming Practices: A Bibliometric Analysis. *West Science Interdisciplinary Studies*. 2023;1(7). doi:10.58812/wsis.v1i07.124.

32. Wezel A, Bellon S, Doré T, Francis C, Vallod D, David C. Agroecology as a science, a movement and a practice. *Sustainable Agriculture*. 2009;29(4):503–515. doi:10.1007/s10457-009-9231-6.
33. Kerr R, Postigo J, Smith P, et al. Agroecology as a transformative approach to tackle climatic, food, and ecosystemic crises. *Current Opinion in Environmental Sustainability*. 2023. doi:10.1016/j.cosust.2023.101275.
34. FAO. *Building a common vision for sustainable food and agriculture: Principles and approaches*. Rome: Food and Agriculture Organization of the United Nations; 2014. Available from: <https://www.fao.org/3/i3940e/i3940e.pdf>[Accessed: 13 April 2025].
35. NRC (National Research Council). *Nutrient Requirements of Dairy Cattle*. 7th rev. ed. Washington, DC: National Academies Press; 2001. doi:10.17226/9825.
36. Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, et al. Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. FAO; 2013.
37. Van Zanten HHE, Herrero M, Van Hal O, Rös E, Muller A, Garnett T, et al. Defining a land boundary for sustainable livestock consumption. *Global Change Biology*. 2019;25(9):3284–3298. doi:10.1111/gcb.14795.
38. Hristov AN, Oh J, Lee C, et al. Mitigation of greenhouse gas emissions in livestock production – A review of technical options for non-CO₂ emissions. FAO Animal Production and Health Paper. 2013;177.
39. Parodi A, Leip A, De Boer IJ, et al. The potential of future foods for sustainable and healthy diets. *Nature Sustainability*. 2018;1(12):782–789. doi:10.1038/s41893-018-0189-7.
40. Pelletier N, Pirog R, Rasmussen R. Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. *Agricultural Systems*. 2010;103(6):380–389. doi:10.1016/j.agsy.2010.03.009.
41. Smetana S, Schmitt E, Mathys A. Sustainable use of *Hermetia illucens* insect biomass for food and feed: A life cycle assessment. *Journal of Cleaner Production*. 2016;137:741–751. doi:10.1016/j.jclepro.2016.07.148.
42. Van den Top HJ, et al. Animal feed and public health: Risks and regulations. *Food Safety Reports*. 2020;12:89–112.
43. Saleemdeen R, Font Vivanco D, Al-Tabbaa A, zu Ermgassen EKHJ. Environmental and health impacts of using food waste as animal feed: A comparative analysis of food waste management options. *Journal of Cleaner Production*. 2017;140:871–880. doi:10.1016/j.jclepro.2016.05.049.
44. Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, et al. Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. FAO; 2013.
45. Narayanan M, Devarayan K, Verma M, et al. Assessing the ecological impact of pesticides/herbicides on algal communities: A comprehensive review. *Aquatic Toxicology*. 2024;268:106851. doi:10.1016/j.aquatox.2024.106851.
46. Luz J. A Narrative Review of Groundwater and Soil Pollution. *Science Insights*. 2022. doi:10.15354/si.22.re081.
47. IPCC. *Climate Change and Land – Special Report*. Intergovernmental Panel on Climate Change. 2019.
48. Yousif I, Hamid A, Aldabaa A, Hassanein S, Rebouh N, Mohamed E, Shokr M. Soil quality indicator-based land productivity modelling for agricultural sustainability. *PLOS ONE*. 2025;20. doi:10.1371/journal.pone.0316840.
49. Kanwal A. A Review on concerns about soil quality and innovative methods for improving soil health. *Emergent Life Sciences Research*. 2021. doi:10.31783/elsr.2021.720513.
50. Thakur R, Verma S, Gupta S, Negi G, Bhardwaj P. Role of Soil Health in Plant Disease Man-

- agement: A Review. *Agricultural Reviews*. 2021. doi:10.18805/ag.r-1856.
51. Wisser D, Grogan D, Lanzoni L, Tempio G, Cinardi G, Prusevich A, Glidden S. Water Use in Livestock Agri-Food Systems and Its Contribution to Local Water Scarcity: A Spatially Distributed Global Analysis. *Water*. 2024. doi:10.3390/w16121681.
 52. Taylor C, Heal G. Fertilizer and Algal Blooms: a Satellite Approach to Assessing Water Quality.
 53. Van den Top HJ, et al. Animal feed and public health: Risks and regulations. *Food Safety Reports*. 2020;12:89–112.
 54. Zhou W, Arcot Y, Medina R, Bernal J, Cisneros-Zevallos L, Akbulut M. Integrated Pest Management: An Update on the Sustainability Approach to Crop Protection. *ACS Omega*. 2024;9:41130–41147. doi:10.1021/acsomega.4c06628.
 55. Newbold T, Hudson LN, Hill SLL, et al. Global effects of land use on local terrestrial biodiversity. *Nature*. 2015;520(7545):45–50. doi:10.1038/nature14324.
 56. Lenné J, Wood D. Crop Diversity in Agroecosystems for Pest Management and Food Production. *Plants*. 2024;13. doi:10.3390/plants13081164.
 57. Rajak P, Roy S, Ganguly A, et al. Agricultural Pesticides – Friends or Foes to Biosphere?. *Journal of Hazardous Materials Advances*. 2023. doi:10.1016/j.hazadv.2023.100264.
 58. Potts SG, Biesmeijer JC, Kremen C, et al. Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*. 2010;25(6):345–353. doi:10.1016/j.tree.2010.01.007.
 59. Smith P, Martino D, Cai Z, et al. Agriculture. In: Metz B, et al., editors. *Climate Change 2007: Mitigation of Climate Change*. Cambridge University Press.
 60. Ozlu E, Arriaga F, Bilen S, Gozukara G, Babur E. Carbon Footprint Management by Agricultural Practices. *Biology*. 2022;11. doi:10.3390/biology11101453.
 61. Nazarov D, Sulimin V, Shvedov V, Larionova N. Renewable energy sources for the agricultural sector. *E3S Web of Conferences*. 2024. doi:10.1051/e3sconf/202454101002.
 62. Hoekstra AY, Mekonnen MM. The water footprint of humanity. *Proceedings of the National Academy of Sciences*. 2012;109(9):3232–3237. doi:10.1073/pnas.1109936109.
 63. Le Mer J, Roger P. Production, oxidation, emission and consumption of methane by soils: A review. *European Journal of Soil Biology*. 2001;37(1):25–50. doi:10.1016/S1164-5563(01)01067-6.
 64. Luo D, Li Y, Yao H, Chapman S. Effect of different carbon sources on methane production and the methanogenic communities in iron-rich flooded paddy soil. *The Science of the Total Environment*. 2022;153636. doi:10.1016/j.scitotenv.2022.153636.
 65. Roque B, Venegas M, Kinley R, et al. Red seaweed (*Asparagopsis taxiformis*) supplementation reduces enteric methane by over 80 percent in beef steers. *PLoS ONE*. 2020;16. doi:10.1371/journal.pone.0247820.
 66. Khoshnevisan B, Fog E, Baladi S, et al. Using the product environmental footprint to strengthen the green market for sustainable feed ingredients; Lessons from a green biomass biorefinery in Denmark. *The Science of the Total Environment*. 2023;162858. doi:10.1016/j.scitotenv.2023.162858.
 67. Smith LG, Kirk GJ, Jones PJ, Williams AG. The greenhouse gas impacts of converting food production in England and Wales to organic methods. *Nature Communications*. 2018;10:4641. doi:10.1038/s41467-019-12622-7.
 68. TÜİK. Organik Tarım İstatistikleri. Türkiye İstatistik Kurumu, Tarım ve Orman Bakanlığı veritabanı; 2023.
 69. Sabuncuoğlu KM, Turgud FK, Şamlı HE. Bazı Böcek Türlerinin Yemlerde Kullanım Olanakları. *Tekirdağ Ziraat Fakültesi Dergisi*. 2018;15(2):73–77.
 70. Surendra KC, Olivier R, Tomberlin JK, et al. Bioconversion of organic wastes into biodiesel and animal feed via insect farming. *Renewable Energy*. 2016;98:197–202.

71. Kroeckel S, Harjes AG, Roth I, et al. Use of insect larvae meal as a protein source for aquafeeds. *Aquaculture Nutrition*. 2012;18(5):538–548.
72. Verbeke W. Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. *Food Quality and Preference*. 2015;39:147–155.
73. T.C. Tarım ve Orman Bakanlığı. Tarım ve Orman Stratejik Planı 2023–2027. Ankara; 2021.
74. OECD. Environmental Performance Review – Netherlands. 2019. <https://www.oecd.org/environment/>.
75. T.C. Tarım ve Orman Bakanlığı. Organik Tarımın Yaygınlaştırılması ve Kontrolü Projesi Raporu. Ankara; 2021.
76. UNFCCC. The Paris Agreement. [Online] <https://unfccc.int/process-and-meetings/the-paris-agreement> [Accessed: 2024].
77. Tester M, Langridge P. Breeding technologies to increase crop production in a changing world. *Science*. 2010;327(5967):818–822. doi:10.1126/science.1183700.
78. Wolfert S, Ge L, Verdouw C, Bogaardt MJ. Big Data in Smart Farming–A review. *Agricultural Systems*. 2017;153:69–80. doi:10.1016/j.agsy.2017.01.023.
79. Lobell DB, Schlenker W, Costa-Roberts J. Climate trends and global crop production since 1980. *Science*. 2011;333(6042):616–620. doi:10.1126/science.1204531.
80. Rosenzweig C, et al. Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. *Proceedings of the National Academy of Sciences*. 2014;111(9):3268–3273. doi:10.1073/pnas.1222463110.
81. Yang Y, Tilman D, Jin Z, Smith P, Barrett C, Zhu Y, et al. Climate change exacerbates the environmental impacts of agriculture. *Science*. 2024;385. doi:10.1126/science.adn3747.
82. Porter JR, et al. Food security and food production systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Intergovernmental Panel on Climate Change. <https://www.ipcc.ch/report/ar5/wg2/>.
83. Sun X, Dou Z, Shurson G, Hu B. Bioprocessing to upcycle agro-industrial and food wastes into high-nutritional value animal feed for sustainable food and agriculture systems. *Resources, Conservation and Recycling*. 2024. doi:10.1016/j.resconrec.2023.107325.
84. Şahin A, Yıldız T. Türkiye’de yem üretim maliyetleri üzerine bir değerlendirme. *Tarım Ekonomisi Dergisi*. 2020;26(2):103–110.
85. OECD/FAO. *Agricultural Outlook 2021–2030*. 2021. <https://www.oecd.org>.
86. Thorne PJ, et al. Sustainable livestock systems for the future. *Outlook on Agriculture*. 2020;49(1):5–11. doi:10.1177/0030727019894361.
87. Silbergeld EK, Graham J, Price LB. Industrial food animal production, antimicrobial resistance, and human health. *Annual Review of Public Health*. 2008;29:151–169. doi:10.1146/annurev.publhealth.29.020907.090904.
88. Pretty J, Toulmin C, Williams S. Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability*.
89. Xie G, Su X, Huang M. Social Media, Knowledge Management, and Learning in Farmer Innovation. *HighTech and Innovation Journal*. 2024. doi:10.28991/hij-2024-05-02-06.
90. UNESCO. Education for Sustainable Development: A roadmap. [Online] <https://en.unesco.org/themes/education-sustainable-development> [Accessed: 2024].
91. Springmann M, et al. Options for keeping the food system within environmental limits. *Nature*. 2018;562(7728):519–525.
92. Siddiqui, S. A., Elsheikh, W., Ucak, İ., Hasan, M., Cleantha Perlita, Z., & Yudhistira, B. (2024). *Replacement of soy by mealworms for livestock feed: A comparative review between soy and mealworms considering environmental aspects*. *Environment, Development and Sustainability*. <https://doi.org/10.1007/s10668-024-04874-1>