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# SMART TECHNOLOGIES FOR LIVESTOCK SUSTAINABILITY AND OVERCOMING CHALLENGES: A REVIEW

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**Abstract**

Smart technology is improving the agricultural sector with sensors, secure data storage and user-friendly interfaces for farmers. Animal husbandry uses smart technologies to enhance sustainability and productivity by improving resource use, remote sensing and the use of drones. Smart technology also supports data-driven decision-making, accurate resource management, and improved overall efficiency. However, realizing its full potential requires addressing economic and ethical challenges. Overcoming these challenges is critical to widespread adoption and long-term success. Collaboration among stakeholders, investment in agricultural technology, and a focus on sustainability are essential to maximizing the benefits of smart technology in livestock development. In conclusion, for smart technology to offer great potential for improving livestock management, addressing the challenges is vital for a resilient livestock future.

**Keywords:** Animal Welfare, Advanced Technology, Efficiency, Environmental Impact.

## 1. INTRODUCTION

Smart technologies (SAT) are revolutionizing the agriculture industry by leveraging cost-effective sensors, secure data storage, and user-friendly interfaces. These developments enhance sustainability and profitability by optimizing resource utilization and boosting productivity. For example, internet-connected sensors and drones allow for continuous monitoring of animal health, improving animal welfare [1], [2], [3].

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To achieve long-term sustainability, integrating modern technology with traditional practices is essential. This integration addresses the challenges of climate change and promotes agricultural sustainability [4], [5], [6]. In addition, SAT attracts young people to the agriculture sector and provides solutions to economic and environmental challenges in livestock management [7], [8].

Sustainable agriculture, while offering significant benefits, encounters challenges such as financial constraints that require economic evaluations and adequate farmer training. In remote regions, these practices also face communication issues, necessitating targeted solutions to achieve sustainability objectives [9], [10], [11].

Automated systems, such as automated milking, raise ethical concerns regarding animal welfare and data privacy [12], [13], [14]. Addressing these issues is critical to ensuring the ethical and sustainable application of technology.

To address these challenges, clear guidelines and strategies need to be developed to address substantive and ethical issues. Future research should focus on improving technology integration with traditional agricultural practices and providing adequate support for farmers' effective adoption of such technology.

In general, smart technology plays a vital role in promoting sustainability and productivity in the agricultural sector. To maximize the benefits of ICT and achieve sustainability and innovation goals, it is necessary to address the financial and ethical challenges that may hinder its implementation. This research explores the impact of smart technology on animal welfare efficiency, productivity and sustainability.

## 2. PROCEDURES

This review studies research in English from 2018 to 2024 to assess the impact of smart technology on animal welfare. The primary focus is on how smart technology affects production efficiency, the agricultural economy, and environmental sustainability, especially in the context of climate change. Initially, 78 studies were reviewed, and after a rigorous selection process, 50 high-quality studies were selected based on their rigor and validity. This review included examining titles, summaries, and full articles, and resolving differences through discussion to ensure accuracy and consistency.

Despite providing valuable insights, the audit has limitations, including selection criteria, focus on English-language publications, period of studies, and differences in study quality. Understanding these constraints is crucial to effectively interpret the results and guide future research in this area.

This review contributed to ongoing research on the impact of smart technology on animal welfare by highlighting the benefits and limitations of current studies. It also provides the basis for further investigation and provides valuable insights into how technology shapes the future of agriculture.

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## 3. FINDINGS

Smart technologies such as remote sensing and the Internet of Things (IoT) greatly enhance efficiency and productivity in animal welfare. These techniques provide accurate data on animal health and behavior, enabling early detection of diseases and reduction of waste, thereby improving production quality and profitability, especially in small farms [15], [16]. Enhancing efficiency and well-being requires better integration of data and validation of technology for sustainability. Technology also addresses environmental and welfare challenges in sheep and goat systems [17], [18].

To make full use of technology, farmers need continued support through research workshops and partnerships. This support helps them to embrace technology and tailor farming practices to their local needs, leading to enhanced innovation and improved production [19], [20].

Animal welfare is challenged by climate change, including rising temperatures and altered rainfall patterns. To address these challenges, strategies such as enhancing heat tolerance, sustainable water management, and reducing chemical use are necessary. These strategies contribute to climate change mitigation and reduce environmental impact [21], [22]. Effective adaptation to climate change also improves farmers' ability to utilize technology and increase productivity.

Investing in improved herd size and feed, land and machinery costs is critical to enhancing productivity and quality. By balancing costs and benefits, farmers can improve financial performance and ensure long-term success [23], [24]. This investment provides the financial basis for the application and development of modern technology.

Modern technologies like remote sensing and artificial intelligence enhance agriculture by providing accurate data that supports decision-making and improves the efficiency of processes such as precise fertilizer distribution and automated milking systems. These applications contribute to more effective resource management and improved animal welfare [25], [26], [27], [28].

The integration of sensing technologies, the Internet, and artificial intelligence has led to the development of integrated sensing systems for real-time decision-making. These systems are used in applications such as animal health monitoring, smart management, and nutrition [29]. Additionally, smart technologies are transforming livestock extension and rural livelihood services through innovations like artificial intelligence, mobile applications, and radio wave identification technology, creating an "information network" that supports improved livestock management [30].

## 4. DISCUSSION

Advanced technologies, including sensors, data analytics, and precision agriculture, are crucial for modernizing animal welfare practices. These technologies enhance productivity and resource efficiency while minimizing environmental impact, making them essential tools in addressing challenges such as climate change and water scarcity [31].

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However, their successful implementation depends on accurate economic assessments and the resolution of issues related to technology access and data privacy [32]. This highlights the interconnected nature of technological progress with the economic and social challenges that accompany it.

The increasing adoption of automation in agriculture has the potential to affect significantly the labor market in this sector. While automation can improve efficiency and productivity, it may also lead to job displacement, particularly in tasks that can be automated easily. This could contribute to widening economic disparities between farmers who can afford to invest in new technology and those who cannot. Additionally, the loss of jobs in agriculture could have broader economic implications, such as affecting related industries and communities [33], [34]. To address these challenges, it is crucial to develop strategies that promote the equitable distribution of the benefits of technological advancements and support those who may be impacted negatively by automation.

Barriers like high costs, limited accessibility in rural regions, and privacy concerns hinder the widespread adoption of technology [35], [36]. These challenges underscore the need for innovative approaches, such as combining traditional practices with modern technology and creating scalable solutions.

Smart technology promises to improve efficiency and productivity, but its effectiveness varies depending on crop types and environmental conditions. This link between technology and its impact on productivity highlights the need for accurate assessments to ensure positive contributions without adverse environmental impacts such as high energy consumption and potential food security issues [33], [37].

To overcome the challenges associated with technology adoption, it is necessary to explore funding opportunities and develop scalable technological solutions. Such strategies should be in line with efforts to address economic and social barriers, including enhancing security and privacy and integrating traditional practices with modern technology [38]. Cooperation between farmers, technology providers and researchers is critical to the success of these strategies.

The integration of smart technology into agriculture, while offering potential benefits, can also lead to increased energy consumption and electronic waste. To mitigate these environmental impacts, it is essential to develop simultaneously strategies for sustainable technology adoption [39]. Additionally, ethical concerns such as privacy rights, economic inequality, and the displacement of traditional skills must be considered carefully to ensure that the environmental and ethical benefits of technology are balanced.

In some studies, Bouali et al., [40] disregard critical environmental impacts such as solar efficiency and storage, which require further assessment. Vishnoi and Goel [41] emphasize technology integration but lack actionable recommendations. Kumari et al., [31] offer a broad overview but they offer no specific strategies to increase acceptance of meat substitutes. Al-Barakeh [32] discusses future improvements in sheep and goat farming without providing concrete strategies for effectiveness.

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Smart agriculture promotes animal health and disease detection through effective resource management [42], [43]. However, challenges such as high costs, limited access and data security issues remain [44], [45]. Future research should focus on enhancing data security, integrating smart technologies and addressing ethical surveillance concerns [46], [47]. Specific studies reveal gaps: Alshehri [42] lacks practical examples; Ellahi et al., [43] limit details about blockchain challenges; Ahamed et al., [44] need a deeper analysis of aquatic feed; Idoje et al., [45] lack practical smart technology strategies; Klerkx et al., [47] require analysis that is more systematic; Dara et al., [46] require an expansion of legal and ethical solutions. Predictive analysis, blockchain and digital platforms are essential to managing market volatility and enhancing sustainability by reducing emissions and improving resource management [48]. Close collaboration between farmers and researchers is needed to ensure that technological benefits extend to all farms, including small farms [49], [50].

Moran and Blair [48] analyze the environmental and health impacts of meat consumption but need to explore deeper potential solutions. Jakku et al., [50] discuss farmers' role in smart farming but lack practical guidance and strategies. Shepherd et al., [49] offer a positive view of digital transformation but they need more practical details and critical analysis. To enhance agricultural efficiency, productivity, and sustainability, future initiatives should prioritize the adoption of Internet of Things (IoT) technologies, invest in research and development, foster collaboration among stakeholders, and provide targeted training programs for breeders.

## 5. CONCLUSIONS

This research highlights the transformative potential of smart technology to revolutionize livestock farming. While these technologies provide significant benefits, such as enhancing efficiency, productivity and sustainability, their adoption is hampered by economic barriers, ethical concerns and environmental impacts. Therefore, to fully realize the potential of smart farming, it is crucial to address these challenges through strategic approaches. For instance, fostering collaboration, investing in development, and promoting sustainable practices are essential steps. By implementing these strategies, livestock farmers can harness the power of technology to improve their operations, contribute to environmental sustainability, and ensure a more resilient and ethical agricultural sector.

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**Conflict of Interest**

Authors have no conflicts of interest.

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**References**

1) Kumar, R., Sinwar, D., Pandey, A., Tadele, T., Singh, V., Raghuwanshi, G. **2022**. IoT Enabled Technologies in Smart Farming and Challenges for Adoption. In: Pattnaik, P.K., Kumar, R., Pal, S. (eds) Internet of Things and Analytics for Agriculture, Volume 3. Studies in Big Data, vol 99. Springer, Singapore. DOI: 10.1007/978-981-16-6210-2_7

2) Gehlot, A., Malik P.K., Singh R., Akram S.V., and Alsuwian T. **2021**. Dairy 4.0: Intelligent Communication Ecosystem for the Cattle Animal Welfare with Blockchain and IoT Enabled Technologies. Applied Sciences, 12(14), 7316. DOI: 10.3390/app12147316

3) Behjati, M., Mohd Noh A.B., Alobaidy H.A., Zulkifley M.A., Nordin R., and Abdullah N.F. **2020**. LoRa Communications as an Enabler for Internet of Drones towards Large-Scale Livestock Monitoring in Rural Farms. Sensors, 21(15), 5044. DOI: 10.3390/s21155044

4) Germer, L.A., Van Middelaar C.E., Oosting S.J., and Gerber P.J. **2023**. When and where are livestock climate-smart? A spatial-temporal framework for comparing the climate change and food security synergies and trade-offs of Sub-Saharan African livestock systems. Agricultural Systems, 210, 103717. DOI: 10.1016/j.agsy.2023.103717

5) Nischalke, S., Wagler I., Tanga C., Allan D, Phankaew C., Ratompoarison C., Razafindrakotomamonjy A., and Kusia E. **2020**. How to turn collectors of edible insects into mini-livestock farmers: Multidimensional sustainability challenges to a thriving industry. Global Food Security, 26, 100376. DOI: 10.1016/j.gfs.2020.100376

6) Henry, B.K., Eckard R.J., Beauchemin K.A. **2018**. Review: Adaptation of ruminant livestock production systems to climate changes. Animal, 12(s2): s445-s456. DOI: 10.1017/S1751731118001301

7) Raheem, D., Dayoub M., Birech R., and Nakiyemba A. **2021**. The Contribution of Cereal Grains to Food Security and Sustainability in Africa: Potential Application of UAV in Ghana, Nigeria, Uganda, and Namibia. Urban Science, 5(1), 8. DOI: 10.3390/ urbansci5010008

8) Abu harb, S., Dayoub M. and Al-Najjar K. **2024**. The impact of agricultural extension program effectiveness on sustainable farming. A survey article. International Journal of Agricultural Technology, 20(2): 477-492.

9) Dayoub, M., Shnaigat S., Tarawneh R.A., Al-Yacoub A.N., Al-Barakeh F., Al-Najjar K. **2024**. Enhancing Animal Production through Smart Agriculture: Possibilities, Hurdles, Resolutions, and Advantages. Ruminants, 4(1):22-46. DOI: 10.3390/ruminants4010003

10) Ndjuluwa, L.N.P., Adebisi J.A., Dayoub M. **2023**. Internet of Things for Crop Farming: A Review of Technologies and Applications. Commodities, 2, 367-381. DOI: 10.3390/commodities2040021

11) Islam, N., Rashid M.M., Pasandideh F., Ray B., Moore S., and Kadel, R. **2020**. A Review of Applications and Communication Technologies for Internet of Things (IoT) and Unmanned Aerial Vehicle (UAV) Based Sustainable Smart Farming. Sustainability, 13(4), 1821. DOI: 10.3390/su13041821

12) Neethirajan, S. **2023**. The Significance and Ethics of Digital Livestock Farming. AgriEngineering, 5(1), 488-505. DOI: 10.3390/agriengineering5010032

13) Belanche, A., Martín-García A.I., Fernández-Álvarez J., Pleguezuelos J., Mantecón Á.R., and Yáñez-Ruiz D.R. **2019**. Optimizing management of dairy goat farms through individual animal data interpretation: A case study of smart farming in Spain. Agricultural Systems, 173, 27-38. DOI: 10.1016/j.agsy.2019.02.002

ISSN: 1673-064X
E-Publication: Online Open Access
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DOI: 10.5281/zenodo.13744058

14) Eastwood, C., Klerkx L., Ayre M. et al. **2019**. Managing Socio-Ethical Challenges in the Development of Smart Farming: From a Fragmented to a Comprehensive Approach for Responsible Research and Innovation. J. Agric. Environ. Ethics, 32, 741–768. DOI: 10.1007/s10806-017-9704-5

15) Alberto, C., Edrein I., Alberto J., and Alejandro F. **2022**. Machine Learning-Based Sensor Data Fusion for Animal Monitoring: Scoping Review. Sensors, 23(12), 5732. DOI: 10.3390/s23125732

16) Neethirajan, S., and Kemp B. **2021**. Digital Livestock Farming. Sensing and Bio-Sensing Research, 32, 100408. DOI: 10.1016/j.sbsr.2021.100408

17) Collins, L., & Smith, L. **2022**. Review: Smart agri-systems for the pig industry. Animal, 16, 100518. DOI: 10.1016/j.animal.2022.100518

18) Silva, S.R., Almeida, M., Ribeiro, D.M., Guedes, C., González Montaña, J.R., Pereira, A.F., Zaralis, K., Geraldo, A., Tzamaloukas, O., Cabrera, M.G., Castro, N., Argüello, A., E., L., J., Á., Martín, M. J., G., L., Stilwell, G., & De Almeida, A.M. **2021**. Extensive Sheep and Goat Production: The Role of Novel Technologies towards Sustainability and Animal Welfare. Animals, 12(7), 885. DOI: 10.3390/ani12070885

19) Dilleen, G., Claffey E., Foley A., and Doolin K. **2023**. Investigating knowledge dissemination and social media use in the farming network to build trust in smart farming technology adoption, Journal of Business and Industrial Marketing, Vol. 38 No. 8, pp. 1754-1765. DOI: 10.1108/JBIM-01-2022-0060

20) Karunathilake, E.M., Le A.T., Heo S., Chung Y.S., and Mansoor S. **2023**. The Path to Smart Farming: Innovations and Opportunities in Precision Agriculture. Agriculture, 13(8), 1593. DOI: 10.3390/agriculture13081593

21) Khoshnevisan, B., Duan N., Tsapekos P., Awasthi M.K., Liu Z., Mohammadi A., Angelidaki I., Tsang D.C., Zhang Z., Pan J., Ma L., Aghbashlo M., Tabatabaei M and Liu H. **2020**. A critical review on livestock manure biorefinery technologies: Sustainability, challenges, and future perspectives. Renewable and Sustainable Energy Reviews, 135, 110033. DOI: 10.1016/j.rser.2020.110033

22) Roy, T., and George K.J. **2020**. Precision Farming: A Step towards Sustainable, Climate-Smart Agriculture. Springer, Singapore. DOI: 10.1007/978-981-32-9856-9_10

23) Kathayat, B., Dixit A.K., Chandel B.S., Sendhil R., Sharma A.K. **2023**. Economic impact of public research investment on livestock productivity: Evidence from India. Agricultural Economics Research Review, Vol. 35, Issue conf. 27-38. DOI: 10.5958/0974-0279.2022.00016.7

24) Seré, C. **2020**. Investing Sustainably in African Livestock Development: Opportunities and Trade-Offs. SSRN: DOI: 10.2139/ssrn.3688901

25) Zhang, L., Guo, W., Lv, C., Guo, M., Yang, M., Fu, Q., & Liu, X. **2024**. Advancements in artificial intelligence technology for improving animal welfare: Current applications and research progress. Animal Research and One Health, 2(1), 93-109. DOI: 10.1002/aro2.44

26) Cogato, A., Brščić, M., Guo, H., Marinello, F., & Pezzuolo, A. **2021**. Challenges and Tendencies of Automatic Milking Systems (AMS): A 20-Years Systematic Review of Literature and Patents. Animals, 11(2), 356. DOI: 10.3390/ani11020356

27) Monteiro, A., Santos, S., & Gonçalves, P. **2021**. Precision Agriculture for Crop and Livestock Farming—Brief Review. Animals, 11(8), 2345. DOI: 10.3390/ ani11082345

28) Remelgado, R., Leutner, B., Safi, K., Sonnenschein, R., Kuebert, C., & Wegmann, M. **2018**. Linking animal movement and remote sensing – mapping resource suitability from a remote sensing perspective. Remote Sensing in Ecology and Conservation, 4(3), 211-224. DOI: 10.1002/rse2.70

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 67 Issue 09 | 2024
DOI: 10.5281/zenodo.13744058

29) Bovo M., Stefano B., Alberto B., Enrica S., **2020**. A Smart Monitoring System for a Future Smarter Dairy Farming. IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor), Trento, Italy, 2020, pp. 165-169, DOI: 10.1109/MetroAgriFor50201.2020.9277547

30) Singh, A., Jadoun Y.S., Brar P.S., Kour G. **2022**. Smart Technologies in Livestock Farming. Springer, Singapore. DOI: 10.1007/978-981-19-1746-2_2

31) Kumari, S., Alam A.N., Hossain M.J., Lee E., Hwang Y. and Joo S. **2023**. Sensory Evaluation of Plant-Based Meat: Bridging the Gap with Animal Meat, Challenges and Future Prospects. Foods, 13(1), 108. DOI: 10.3390/foods13010108

32) Al-Barakeh, F., Khashroum A.O., Tarawneh R.A., Al-Lataifeh F.A., Al-Yacoub A.N., Dayoub M., Al-Najjar K. **2024**. Sustainable Sheep and Goat Farming in Arid Regions of Jordan. Ruminants. 4(2):241-255. DOI: 10.3390/ruminants4020017

33) Dawkins, M.S. **2021**. Does Smart Farming Improve or Damage Animal Welfare? Technology and What Animals Want. Frontiers in Animal Science, 2, 736536. DOI: 10.3389/fanim.2021.736536

34) Giersberg, M.F., & Meijboom, F.L. **2021**. Smart Technologies Lead to Smart Answers? On the Claim of Smart Sensing Technologies to Tackle Animal Related Societal Concerns in Europe Over Current Pig Husbandry Systems. Frontiers in Veterinary Science, 7, 588214. DOI: 10.3389/fvets.2020.588214

35) Akhigbe, B.I., Munir, K., Akinade, O., Akanbi, L., & Oyedele, L.O. **2021**. IoT Technologies for Livestock Management: A Review of Present Status, Opportunities, and Future Trends. Big Data and Cognitive Computing, 5(1), 10. DOI: 10.3390/bdcc5010010

36) Gebresenbet, G., Bosona, T., Patterson, D., Persson, H., Fischer, B., Mandaluniz, N., Chirici, G., Zacepins, A., Komasilovs, V., Pitulac, T., & Nasirahmadi, A. **2023**. A concept for application of integrated digital technologies to enhance future smart agricultural systems. Smart Agricultural Technology, 5, 100255. DOI: 10.1016/ j.atech. 2023.100255

37) Tedeschi, L.O., Greenwood, P.L., & Halachmi, I. **2021**. Advancements in sensor technology and decision support intelligent tools to assist smart livestock farming. Journal of Animal Science, 99(2). DOI: 10.1093/jas/skab038

38) Jain, Rahul and Prajapati, Dhiren, Climate Change and Animal Health: Impacts, Challenges, and Mitigation Strategies. **2023**. Open Access Journal of Veterinary Science & Research (OAJVSR), Volume 8, Issue 2, https://ssrn.com/ abstract=4640288

39) Díaz, L., Zambrano, E., Flores, M.E., Contreras, M., Crispín, J.C., Alemán, G., & Bobadilla, N.A. **2021**. Ethical considerations in animal research: the principle of 3R's. *Revista de investigacion clinica*, *73*(4), 199-209. DOI: 10.24875/ric. 20000380

40) Bouali, E.T., Abid M.R., Boufounas E.M., Hamed T.A and Benhaddou D. **2022**. Renewable Energy Integration into Cloud and IoT-Based Smart Agriculture, IEEE Access, vol. 10, pp. 1175-1191. DOI: 10.1109/ACCESS.2021.3138160

41) Vishnoi, S., and Goel R.K. **2023**. Climate smart agriculture for sustainable productivity and healthy landscapes. Environmental Science and Policy, 151, 103600. DOI: 10.1016/j.envsci.2023.103600

42) Alshehri, D.M. **2023**. Blockchain-assisted internet of things framework in smart livestock farming. Internet of Things, 22, 100739. DOI: 10.1016/j.iot.2023.100739

43) Ellahi, R.M., Wood L.C., and Bekhit, A.E. **2022**. Blockchain-Based Frameworks for Food Traceability: A Systematic Review, Foods, 12(16), 3026. DOI: 10.3390/foods12163026

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 67 Issue 09 | 2024
DOI: 10.5281/zenodo.13744058

44) Ahamed, M.S., Sultan M., Shamshiri R.R., Rahman M.M., Aleem M., and Balasundram S.K. **2023**. Present status and challenges of fodder production in controlled environments: A review. Smart Agricultural Technology, 3, 100080. DOI: 10.1016/j.atech.2022.100080

45) Idoje, G., Dagiuklas T., and Iqbal M. **2021**. Survey for smart farming technologies: Challenges and issues. Computers and Electrical Engineering, 92, 107104. DOI: 10.1016/j.compeleceng.2021.107104

46) Dara, R., Hazrati Fard S.M., and Kaur J. **2022**. Recommendations for ethical and responsible use of artificial intelligence in digital agriculture. Frontiers in Artificial Intelligence, 5, 884192. DOI: 10.3389/frai.2022.884192

47) Klerkx, L., Jakku E., and Labarthe P. **2019**. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. NJAS - Wageningen Journal of Life Sciences, 90-91, 100315. DOI: 10.1016/j.njas.2019.100315

48) Moran, D. and Blair K. **2021**. Review: Sustainable livestock systems: Anticipating demand-side challenges. Animal, 15, 100288. DOI: 10.1016/ j.animal. 2021.100288

49) Shepherd, M., Turner J.A., Small B., and Wheeler D. **2020**. Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution. Journal of the Science of Food and Agriculture, 100(14), 5083-5092. DOI: 10.1002/jsfa.9346

50) Jakku, E., Taylor B., Fleming A., Mason C., Fielke S., Sounness C., and Thorburn P. **2019**. "If they don't tell us what they do with it, why would we trust them?" Trust, transparency and benefit-sharing in Smart Farming. NJAS - Wageningen Journal of Life Sciences, 90-91, 100285. DOI: 10.1016/j.njas.2018.11.002