sustainability

MDPI

Editorial

Sustainable Agriculture and Climate Resilience

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For decades, human-induced climate change has been scientifically predicted and observed to cause devastating global phenomena globally. It has also been assessed and reported under the Intergovernmental Panel on Climate Change (IPCC) umbrella. Since the beginning, adaptation, resilience, and mitigation have repeatedly been considered to be the main pillars of the response to climate change [1]. Even before anthropogenic climate change, adaptation was the central concept of evolution [2,3] since the publication of *The Origin of Species* by Charles Darwin because it includes all the physical, chemical, and biological mechanisms or behavioural changes by which organisms reduce their vulnerability to their environment [4]. Yet, to manage socioeconomic aspects and behaviours and sustainable development under climate change, resilience must be combined with adaptation [5] for organisms to self-organise and adapt quickly and efficiently [4].

Agriculture, which is fundamental for human survival, integrates biology, chemistry, and physics for food and feed supplies, and agrosystems largely depend on natural and climatic processes. This dependence increases their vulnerability to climate-related risks and uncertainties, be they biotic (i.e., pests, diseases, etc.), abiotic (i.e., temperature, humidity, radiation, etc.), or socio-economic conditions with different impact frequencies and intensities. Nevertheless, agriculture contributes a significant share of the GHG emissions that cause climate change, drastically threatening our existence.

The literature suggests that sustainable agriculture can preserve natural ecosystems and mitigate climate change. Yet, sustainable agriculture is, on one side, a transdisciplinary model that integrates adaptation practices and tools to make agrosystems more resilient [6,7]; however, on the another side, sustainable agriculture is still intensively debated in the scientific community, and there is no agreed definition. The concept is misused and misinterpreted [7].

Therefore, this Special Issue comprises a group of reviews and research papers analysing one or different aspects of agricultural resilience to climate change. The contributions include:

On one side, methodological reviews, such as systematic reviews and bibliometric analyses, are evidence-based and robust approaches with several applications in agrosystem and climate change science used to draw scientific conclusions for decision makers and identify the research gaps and opportunities. Thus, this book includes a systematic review assessing the tools for climate adaptation in coffee agrosystems worldwide (contribution 1) and a bibliometric network analysis determining the adaptation of global water systems to climate change (contribution 2).

Conversely, these research articles explore the interconnections and trade-offs between different agriculture and agrifood practices and their adaptation and resilience capability under climate change conditions.

In agrifood practices, Zahidi et al. (contribution 3) analysed the logic of proximity and its impacts on the resilience of the rose agrifood system in Kalâat M'gouna (Morocco). In addition, Alobid et al. (contribution 4) used a linear model to estimate the food shortage in Egypt and suggest the redistribution of crops in terms of production, food demand,

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and land reallocation. Another group proposed adapting transformation methods in the agrifood industry (contribution 5). The agricultural practices include the assessment of different sustainable practices classified as nutrient (contributions 6–8), soil (contribution 9), water (contribution 11), and crop management (contributions 11–16). The results demonstrate the importance of these agricultural practices in improving the agrosystems' resilience and adaptation to climate change (Table 1).

Table 1. A summary of the published manuscripts.

Type	Manuscript	Method	Climate Science	Management Category	Main Results
Review	List of Contributions 1: Faraz et al. 2023	This article adopted a systematic approach to searching out information from the literature about different modelling approaches to assess the climate change impacts or/and adaptation on coffee crops worldwide. This review included all the scientific publications from the date of the first relevant article until the end of 2022 and screened 60 relevant articles.	Impacts and Adaptation	Knowledge Management	The selected manuscripts describe qualitative and quantitative modelling tools used to simulate the climate impact on crop suitability (55% of the results), crop productivity (25% of the studies), and pests and diseases (20% of the results). According to the analysed literature, MaxEnt is the leading machine learning model used to assess the climate suitability of coffee agrosystems. The most authentic and reliable model in pest distribution is the Insect Life Cycle Modelling Software (ILCYM) (version 4.0). The scientific evidence shows a lack of adaptation modelling, especially in shading and irrigation practices, which crop models can assess.
	List of Contributions 2: Sawassi and Khadra 2021	This research draws on a systematic bibliometric study of the data generated from the Web of Science research engine between 1990 and 2019, combined with statistical analysis, to explore the academic publication trends and identify the strategic gaps and opportunities in global scientific research dealing with the climate change impacts and uncertainties associated with the various dimensions of hydrologic variability; water system adaptation has risen to the top of global agenda.	Adaptation and Resilience	Knowledge Management	This analysis shows consistent national and international collaboration among authors, institutions, and countries. This statistical examination shows that the adaptation-informed literature on water systems remains fragmented and predominantly centred on framing water resource planning and management and water engineering and infrastructure. This analysis also revealed a relatively skewed understanding of various critical dimensions, such as governance, integrated water resources management, and stakeholder engagement, which are crucial for planning and implementing an efficient adaptation process. The observations reflect the need to build water-related adaptive approaches based on a thorough understanding of the potential climate uncertainties, rather than generically addressing all the uncertainties in one scenario analysis.
Research	List of Contributions 3: Zahidi et al. 2022	This methodology integrates the traditional and scientific knowledge by identifying the proximity and the valorisation modes of the territorial "rose" resource through analysing the actors in this system, while proposing improvements for sustainable development.	Adaptation and Resilience	Knowledge Management	The results of 57 semi-conductive interviews verify the domination of traditional proximities (geographical, organisational, relational, etc.) at the level of interactions between the actors. On the other hand, the relationships are sufficient based on the knowledge.
	List of Contributions 4: Alobid et al. 2021	The authors propose a linear model for crop redistribution in terms of production, food demand, and land reallocation to find the best solution to minimise the Food Gap (FG) under a set of constraints.	Adaptation and Resilience	Agrifood Management	The results found that the modelled FG value increased steadily from 2005 to 2017, and then it declined slightly. Furthermore, a significant water loss was noticed. There was a considerable difference, reaching around 25 billion m^3, between the water consumed by the studied crops and the total amount of renewable water. Moreover, the calculation of food demand with the estimated production and the redistribution of cropland reallocations were performed to achieve the best model fit between the crops in terms of minimising the FG in Egypt.
	List of Contributions 5: Benković-Lačić et al. 2023	The study assessed four drying methods of organic production and the laboratory analysis of polyphenolic compounds and antioxidants were conducted.	Adaptation and Resilience	Agrifood Management	The highest polyphenolic compound contents and antioxidant activity levels were measured in the flower samples dried in the sunlight. The most abundant compounds in all the samples were α-bisabolol oxide A (from 19.6 to 24.3%), bisabolol oxide B (from 19.3 to 23.2%), and β-farnesene E (from 15.9 to 25.5%).

Table 1. *Cont.*

Type	Manuscript	Method	Climate Science	Management Category	Main Results
Research	List of Contributions 6: Piscitelli et al. 2022	This study proposed a combination of phosphate rock with food processing by-products, such as olive pomace, barley spent grain, and citrus pomace, to increase phosphate rocks' solubility and the efficient use of P in organic agriculture.	Adaptation and Resilience	Nutrient Management	The mixtures' P release values ranged between 80% and 88%, whereas the phosphate rock lost 23% of its P over 30 days. Phosphate rock showed a constant water-soluble P fraction, whereas the mixtures exhibited a highly water-soluble P fraction that tended to decrease over time.
	List of Contributions 7: Leogrande et al. 2022	This study evaluated the effects of the foliar applications of a vegetable- and brown-algae-based extract (*Ascophyllum nodosum* (L.) Le Jol. on grapes (*Vitis vinifera* L. cv. Montepulciano) and olives (*Olea europaea* L. cv. Coratina) and its agronomic performance in two field experiments in the Apulia region.	Adaptation and Resilience	Nutrient Management	The results highlight that the crop responses differ in grape and olive orchards. The biostimulant application determined significant increases in the bunches' development (+9.5%) and weight (+10%) compared to those of the untreated control. In the olive orchard, the yield was not significantly influenced by biostimulant application, whereas we observed more quality improvements in the olive oil of the treated plants compared to those of the control.
	List of Contributions 8: El Handi et al. 2021	The study compares the leaf ionome of four important autochthonous Moroccan olive cultivars and eight Mediterranean varieties introduced in Morocco to develop hypotheses related to the resistance or susceptibility of the Moroccan olive trees to *Xylella fastidiosa* (Xf). Leaf ionomes, mainly Ca, Cu, Fe, Mg, Mn, Na, Zn, and P, were determined using inductively coupled plasma optical emission spectroscopy (ICP-OES). These varieties were also screened for their total phenolics and flavonoids content.	Adaptation and Resilience	Nutrient Management	The results showed that the varieties 'Leccino', 'Arbosana', and 'Arbequina' consistently contained higher Mn, Cu, and Zn and lower Ca and Na levels compared with those of the higher pathogen-sensitive 'Ogliarola salentina' and 'Cellina di Nardò'. Our findings suggest that 'Arbozana', 'Arbiquina', 'Menara', and 'Haouzia' may tolerate the infection by X. fastidiosa to varying degrees, which provides additional support for 'Leccino' having resistance to X. fastidiosa and suggests that both 'Ogliarola salentina' and 'Cellina di Nardö' are likely sensitive to X. fastidiosa infection.
Research	List of Contributions 9: Benković et al. 2023	The comparison of soil compaction with different tillage systems was performed, and the pressure of the front and rear tires of tractors during sowing was a subfactor of this study.	Adaptation and Resilience	Soil Management	The tillage systems applied resulted in different soil compaction outcomes. Thus, the deepest tillage had the lowest resistance, and the shallowest tillage had the highest resistance in all three experimental years. The penetrometer measurements showed the significant influence of the lowest tire pressure on reducing compaction and the highest pressure on increasing soil compaction.
	List of Contributions 10: Dragonetti and Khadra 2023	Hydrus-1D model calibration and scenario simulations were used to modulate the salt tolerance threshold.	Adaptation and Resilience	Water Management	With long-term irrigation, based on the irrigation frequency, the model demand (M) scenario achieved better root water and N uptake results than the farmer demand (F) scenario.
	List of Contributions 11: Japundžić-Palenkić et al. 2022	Greenhouse and field experiments on two pepper cultivars were used to test the effect of a Plasma-Activated Water (PAW) treatment of seeds on growth. The results were statistically studied using Fisher's test.	Adaptation and Resilience	Crop Management	The lowest measured parameter values were obtained in the open field without the PAW treatment. The peppers in a greenhouse grew faster and had a better quality after the PAW treatment.
	List of Contributions 12: Yasmeen et al. 2022	A pot experimental set-up was used to test the adaptation of two lentil cultivars to drought and melatonin treatment for adaptation. Measurements were performed and analysed statistically using ANOVA variance analysis.	Adaptation and Resilience	Crop Management	The results showed that increasing the levels of soil water deficit significantly decreased numerous crops' morphological and biochemical characteristics and increased the concentrations of malondialdehyde (MDA) and hydrogen peroxide (H_2O_2). Melatonin application helps contrast these impacts for better adaptation. Two different lentil varieties responded differently to drought; therefore, selecting crop variety is also an adaptation strategy.
	List of Contributions 13: Romanjek Fajdetić et al. 2022	Greenhouse and field experiments on two lettuce cultivars were conducted to test the effect of a Plasma-Activated Water (PAW) treatment of seeds on growth. The results were statistically studied using Fisher's test.	Adaptation and Resilience	Crop Management	The results found that the lettuces from the PAW-treated seeds had better results in the first measurement for both cultivars, with no statistically significant effects on the root system. It was also found that cultivation in a greenhouse resulted in a higher-quality plants than those in the open field.

Table 1. *Cont.*

Type	Manuscript	Method	Climate Science	Management Category	Main Results
Research	List of Contributions 14: Ostrowska et al. 2022	This study investigates specific responses (water content, gas exchange intensity, photosynthetic apparatus activity, chlorophyll content, plant height, and biological membrane integrity) of spring wheat (C3 photosynthesis) and maise (C4 photosynthesis) to drought and flooding stresses at the third leaf stage.	Adaptation and Resilience	Crop Management	A specific wheat response under drought and flooding conditions involved an ET_0/RC ratio increase, describing electron transport flux converted into a single reaction centre in PSII. Correlations between electrolyte leakage, the probability of electron transport beyond the plastoquinone Q_A, and the amount of energy used for the electron transport were also found. A Maise expressed an increase in stomatal conductance during flooding. A significant correlation between PN/Ci and relative water content was also exhibited.
	List of Contributions 15: Frem et al. 2022	This paper evaluates the effect of five safe biological treatments (olive soap, sodium bicarbonate, garlic extract, horsetail, and compost tea) in managing powdery mildew.	Adaptation and Resilience	Crop Management	The plants treated with sodium bicarbonate and garlic extract were the least affected by the powdery mildew regarding disease incidence and severity, while tea compost proved to be the least effective product.
	List of Contributions 16: El Handi et al. 2022	This research assessed the presence of *Xylella fastidiosa* (Xf), a pervasive emerging pathogen, in Morocco. The hosts were inspected and sampled randomly over different environments, including symptomatic and asymptomatic plants. The samples were screened using the DAS-ELISA commercial kit, while further analyses were carried out on the doubtful samples by PCR.	Impacts and Adaptation	Crop Management	The results of both the tests did not show any positive sample in the investigated areas. This finding is an update on the Xf situation in Morocco and confirms that this country is still free from this bacterium, at least in the monitored regions.

Finally, this collection of sustainable practices in agriculture fills a gap in the scientific literature that the authors have already addressed in previous works, where transdisciplinary approaches and integration of management practices are still missing. Yet we are still far from a holistic approach which takes into account the three dimensional model of sustainable development with the economic, social and environmental axes.

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List of Contributions:

1. Faraz, M.; Mereu, V.; Spano, D.; Trabucco, A.; Marras, S.; El Chami, D. A Systematic Review of Analytical and Modelling Tools to Assess Climate Change Impacts and Adaptation on Coffee Agrosystems. *Sustainability* **2023**, *15*, 14582. https://doi.org/10.3390/su151914582.
2. Sawassi, A.; Khadra, R. Bibliometric Network Analysis of "Water Systems' Adaptation to Climate Change Uncertainties": Concepts, Approaches, Gaps, and Opportunities. *Sustainability* **2021**, *13*, 6738. https://doi.org/10.3390/su13126738.
3. Zahidi, M.; Ayegou, J.; Ait Hou, M. Proximities and Logics of Sustainable Development of the Territorial Resource: The Case of the Localised Agro-Food System of Kalâat M'gouna in Morocco. *Sustainability* **2022**, *14*, 15842. https://doi.org/10.3390/su142315842.
4. Alobid, M.; Derardja, B.; Szűcs, I. Food Gap Optimization for Sustainability Concerns, the Case of Egypt. *Sustainability* **2021**, *13*, 2999. https://doi.org/10.3390/su13052999.
5. Benković-Lačić, T.; Orehovec, I.; Mirosavljević, K.; Benković, R.; Ćavar Zeljković, S.; Štefelová, N.; Tarkowski, P.; Salopek-Sondi, B. Effect of Drying Methods on Chemical Profile of Chamomile (*Matricaria chamomilla* L.) Flowers. *Sustainability* **2023**, *15*, 15373. https://doi.org/10.3390/su152115373.
6. Piscitelli, L.; Bennani, Z.; El Chami, D.; Mondelli, D. A Circular Economy Model to Improve Phosphate Rock Fertiliser Using Agro-Food By-Products. *Sustainability* **2022**, *14*, 16228. https://doi.org/10.3390/su142316228.
7. Leogrande, R.; El Chami, F.G.; Di Carolo, M.; Piegari, G.; Elefante, M.; Perrelli, D.; Dongiovanni, C. Biostimulants for Resilient Agriculture: A Preliminary Assessment in Italy. *Sustainability* **2022**, *14*, 6816. https://doi.org/10.3390/su14116816.
8. El Handi, K.; Hafidi, M.; Habbadi, K.; El Moujabber, M.; Ouzine, M.; Benbouazza, A.; Sabri, M.; Achbani, E.H. Assessment of Ionomic, Phenolic and Flavonoid Compounds for a Sustainable Management of *Xylella fastidiosa* in Morocco. *Sustainability* **2021**, *13*, 7818. https://doi.org/10.3390/su13147818.
9. Benković, R.; Jug, D.; Šumanovac, L.; Jug, I.; Mirosavljević, K.; Domagoj Zimmer, D.; Teuta Benković-Lačić, T. Mechanical Soil Resistance Influenced by Different Tillage Systems and Tractor Tire Pressures. *Sustainability* **2023**, *15*, 10236. https://doi.org/10.3390/su151310236.
10. Dragonetti, G.; Khadra, R. Assessing Soil Dynamics and Improving Long-Standing Irrigation Management with Treated Wastewater: A Case Study on Citrus Trees in Palestine. *Sustainability* **2023**, *15*, 13518. https://doi.org/10.3390/su151813518.
11. Japundžić-Palenkić, B.; Benković, R.; Benković-Lačić, T.; Antunović, S.; Japundžić, M.; Romanjek Fajdetić, N.; Mirosavljević, K. Pepper Growing Modified by Plasma Activated Water and Growth Conditions. *Sustainability* **2022**, *14*, 15967. https://doi.org/10.3390/su142315967.
12. Yasmeen, S.; Wahab, A.; Saleem, M.H.; Ali, B.; Qureshi, K.A.; Jaremko, M. Melatonin as a Foliar Application and Adaptation in Lentil (*Lens culinaris* Medik.) Crops under Drought Stress. *Sustainability* **2022**, *14*, 16345. https://doi.org/10.3390/su142416345.
13. Romanjek Fajdetić, N.; Benković-Lačić, T.; Mirosavljević, K.; Antunović, S.; Benković, R.; Rakić, M.; Milošević, S.; Japundžić-Palenkić, B. Influence of Seed Treated by Plasma Activated Water on the Growth of *Lactuca sativa* L. *Sustainability* **2022**, *14*, 16237. https://doi.org/10.3390/su142316237.
14. Ostrowska, A.; Hura, T. Physiological Comparison of Wheat and Maize Seedlings Responses to Water Stresses. *Sustainability* **2022**, *14*, 7932. https://doi.org/10.3390/su14137932.
15. Frem, M.; Nigro, F.; Medawar, S.; El Moujabber, M. Biological Approaches Promise Innovative and Sustainable Management of Powdery Mildew in Lebanese Squash. *Sustainability* **2022**, *14*, 2811. https://doi.org/10.3390/su14052811.
16. El Handi, K.; Hafidi, M.; Sabri, M.; Frem, M.; El Moujabber, M.; Habbadi, K.; Haddad, N.; Benbouazza, A.; Abou Kubaa, R.; Achbani, E.H. Continuous Pest Surveillance and Monitoring

Constitute a Tool for Sustainable Agriculture: Case of *Xylella fastidiosa* in Morocco. *Sustainability* **2022**, *14*, 1485. https://doi.org/10.3390/su14031485.

References

1. IPCC. Climate Change: The 1990 and 1992 IPCC Assessment. In *IPCC First Assessment Report Overview and Policymaker Summaries and 1992*; IPCC Supplement; Intergovernmental Panel on Climate Change (IPCC): Geneva, Switzerland, 1992.
2. Thornhill, R. The concept of an evolved adaptation. In Proceedings of the Ciba Foundation Symposium, London, UK, 8–10 April 1997; Volume 208, pp. 4–13, Discussion 13–22. [CrossRef]
3. Williams, G.C. *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought*; Princeton University Press: Princeton, NJ, USA, 1966.
4. IPCC. Climate change 2007: Appendix to synthesis report. In *Climate Change 2007: Synthesis Report*; Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC); Baede, A.P.M., van der Linden, P., Verbruggen, A., Eds.; IPCC: Geneva, Switzerland, 2007; pp. 76–89.
5. Denton, F.; Wilbanks, T.J.; Abeysinghe, A.C.; Burton, I.; Gao, Q.; Lemos, M.C.; Masui, T.; O'Brien, K.L.; Warner, K. Climate-resilient pathways: Adaptation, mitigation, and sustainable development. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability*; Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J, Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., et al., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 1101–1131.
6. Howden, S.M.; Soussana, J.-F.; Tubiello, F.N.; Chhetri, N.; Dunlop, M.; Meinke, H. Adapting agriculture to climate change. *PNAS* **2007**, *104*, 19691–19696. [CrossRef] [PubMed]
7. El Chami, D. Towards sustainable organic farming systems. *Sustainability* **2020**, *12*, 9832. [CrossRef]