



E-learning in Regenerative and Sustainable Farming - a Scoping Review

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Abstract—Regenerative farming is a practice for sustainable agriculture that aims to restore soil health, enhance biodiversity, and mitigate climate change by storing atmospheric carbon in farmlands. However, there remains a significant educational gap in disseminating these practices, particularly in the e-learning domain. This scoping review aims to explore the state-of-the-art in e-learning and computer-supported education in regenerative and sustainable farming. The current study seeks to investigate how digital approaches are being utilized to deliver sustainable agriculture education. As a result, this paper summarizes the objectives and findings of 25 original research articles found in the intersection of e-learning and sustainable farming. Four main categories for studies were distinguished: Curriculum design and pedagogical approaches, e-learning platforms and technology implementation, evaluation of knowledge in different stakeholder groups, and review studies of education and learning technologies in agriculture. The importance of digital learning is highlighted contributing to both the development of sustainable food systems and the pedagogic practices of agricultural education.

Keywords—*regenerative farming; sustainable agriculture; literature review; scoping review*

I. INTRODUCTION

Regenerative farming refers to agricultural practices where improving the quality of soil is equally important as producing food [1]. Regenerative practices have been attributed to not only increase net farm profits [2] but also improve the uptake and storage of carbon dioxide (CO₂) in soil [3], [4].

It is evident that such practices are of utmost importance in the global food production. However, there is a need for development in the distribution of sustainable and regenerative knowledge to agriculture professionals and stakeholders [5]. Thus, this study aims to shed light on how e-learning (or online learning) resources have been studied in the farming context. The objective is to answer the following research question: To what extent is e-learning present in the domain of regenerative farming and sustainable agriculture education?

The rest of the paper is organized as follows. Section II presents related work on regenerative and sustainable agriculture. Section III describes the chosen research methodology used in the study, namely the scoping review and its execution. Next, Section IV the synthesized results of the review. Finally, Section V concludes the paper by discussing the findings, and limitations of the work.

II. RELATED WORK

Sustainable agriculture plays a crucial role in global food production [6], [7]. Regenerative farming is one of the key methods to achieve a lesser carbon footprint, as it has been demonstrated to improve the quality of soil in farmlands, while simultaneously producing high quality food [1].

The use of ICT and e-learning in agricultural education has been found advantageous. In particular, e-learning technologies have improved learning generally, and access to resources [8]. Given that farmers typically live in low-density populated areas, outside the reach of universities, providing education online is crucial.

However, the adoption of e-learning and ICT learning tools in the agriculture sector is still in its early stages. For example, the study of Khan [5] highlights several challenges, including illiteracy and limited ICT access among farmers. In a similar vein, Balakrishnan et al. [9] distinguish delayed responses to online queries, high cost of establishment, lack of time and ensuring up-to-date online information as some of the issues affecting farmers' e-learning experience.

Extant literature has identified several research gaps in the field. Cooreman [10] and Triste [11] both highlight the need for a deeper understanding of the learning processes and characteristics that can drive sustainable farming practices. Jimenez [12] and Balakrishnan [9] point to the importance of content quality and technological constraints in e-learning platforms, while Odunaike (2014) suggests the potential of cloud computing in mitigating these challenges. Chang [13] and Allahyari [14] emphasize the need for effective implementation and extension-education methods, to support sustainable agriculture. The study of Moschitz [15] underscores the role of learning and innovation networks in promoting sustainable agriculture.

These studies highlight the need for further research on the design, implementation, and effectiveness of e-learning platforms for sustainable farming. As such, this paper aims to take steps to synthesize the key research areas in the field. Thus, a systematic review is necessary to delineate the scope of available knowledge.

III. RESEARCH METHOD

This scoping review aims to investigate the intersection of digital or computer-supported education and regenerative farming practices. A scoping review seeks to present an overview of a potentially large and diverse body of literature whereas systematic reviews synthesize a smaller number of studies related to a focused research question [16]. As regenerative and sustainable farming are relatively new concepts, we expect the literature around e-learning in this domain to be scattered. Thus, a scoping review [17], [18] was selected as the research method. Scoping reviews are "particularly useful when a body of literature has not yet been comprehensively reviewed" [18]. They are used to answer broad research questions, synthesizing available evidence with a reproducible method [19], [18], [20].

In this study, the Google Scholar search engine was used to search for articles. Beyond freely available articles, such as open access publishing or author-provided pre-prints, the author had access to the following sources of articles (databases): ACM Digital Library, BrowZine, Cinahl, Emerald Insight, Sage, Science Direct (Elsevier), Springer, and Wiley.

The following search string was crafted to perform the search: ((*"regenerative farming"*)OR(*"sustainable farming"*)OR(*"sustainable agriculture"*))AND(*"e-learning"*). This string was designed to capture the broad spectrum of regenerative and sustainable farming practices together with e-learning.

Google Scholar has at times been criticized as the search engine for systematic reviews, as the Google Page Rank algorithm sorts the search results based on unknown heuristics. However, prior systematic reviews have used solely Google Scholar to reach a good coverage of papers, as demonstrated by the review(s) of Garousi et al. [21].

In order to reach good coverage with our search, we followed the practice by Garousi (2020) [22]: The search should continue as long as there was "at least one result in the Nth page". This approach ensured the coverage of the results until a point of "saturation" was reached.

Next, a set of inclusion and exclusion criteria was crafted. Included papers had to be explicitly related to farming or agricultural studies and include an application or study about e-learning. The exclusion criteria were set to maintain the academic integrity of the review: Papers not written in English, very short articles such as short poster abstracts, and inaccessible articles, including those behind paywalls with no open access versions, were excluded. Additionally, we only included peer-reviewed scientific articles, and discarded papers with no publication venue or date.

A three-step search protocol was adopted to review the papers:

- 1) **Title Review:** Initially, the title of each article was examined to determine its relevance. Papers were categorized as 'include', 'exclude', or 'investigate further'.

- 2) **Abstract Screening:** For titles that were unclear, abstracts were read to determine inclusion or exclusion.
- 3) **Full Article Examination:** A review of the full article was conducted for papers that were shortlisted through the previous steps. This examination ranged from a quick inspection to an in-depth reading, depending on the paper's relevance.

Following the search protocol, the author collected the following data from the original studies: the country of the study, objectives (for example, research question), and key findings presented. This allowed for an analysis of the trends and variations in the found articles.

IV. RESULTS

Following the search protocol, a total of 110 search hits (11 pages) were screened. After removing duplicates, 42 papers were selected based on the titles. In cases where the relevance of the paper was not immediately clear from the title, a screening of the abstract was also conducted immediately.

Next, the abstracts of the all papers were inspected. This left an initial corpus of 29 papers that were included in our analysis. A further 2 papers were discarded after reading the full articles. Thus we proceeded to gather data from the remaining 28 papers, which now serve as the data source of this study. After careful inspection of all the papers, some of which were still discarded based on content, we were left with 25 original research papers to synthesize.

It can be said that research outputs in the domain of regenerative and sustainable farming have started to gain more traction, as most of the papers are from 2013 or after. The included papers are summarized in Tables I and II.

From the scoping review, we highlight the following categories of studies. First, papers related to **curriculum design and pedagogical approaches**. These include the studies by Athuman et al. [25], Baptista et al. (2019 [31], 2021 [30]), Cory-Watson [39], Lieblein et al. [45], Makrakis et al. [27], and Sitji [32] which focus on developing curricula and innovative pedagogical strategies for sustainable agriculture education.

Next, papers were related to **e-learning platforms and technology implementation**. Studies of Herdon et al. [42], Chunwijitra et al. [33], Rajendram et al. [37], and Abdon & Raab [44] explore the use of e-learning tools and platforms in agricultural education, reporting on their advantages and challenges.

Surveys and evaluation of knowledge type studies were also common. The studies by Estandarte et al. [26], Oluwasusi et al. [28], Menalled et al. [41], and Guiné et al. [35] all used surveys to assess knowledge and practices related to sustainable agriculture among different stakeholder groups.

Finally, **review studies and descriptive analysis approaches** were the most common type of research. Among the many descriptive reviews, Farooq [24],

TABLE I
SUMMARY OF STUDIES ON DIGITAL EDUCATION IN REGENERATIVE AND SUSTAINABLE AGRICULTURE BETWEEN 2017 AND 2023

Author(s)	Year	Country	Study Type	Objective	Key Findings
Rehman et al. [23]	2023	Pakistan, Turkey, and Oman	Review	Explore curricula transformations and alternative pedagogical approaches in sustainable agriculture	The study highlights the importance of transdisciplinary education, experiential learning, and hybrid learning models in enhancing students' understanding and engagement
Farooq [24]	2023	Oman	Review	Explore transformative learning pedagogies in sustainable agriculture	Importance of learner-centeredness, experiential learning, critical thinking, interdisciplinary collaboration, and technology in education
Athuman et al. [25]	2023	Tanzania	Descriptive / Review	Investigate the role of agricultural science education in promoting sustainable farming practices	The study emphasizes the need for evaluating the impact of agricultural education on promoting sustainable practices
Estandarte et al. [26]	2022	Georgia	Survey	Examine knowledge of sustainable food systems among students and food industry representatives	Students and food industry representatives had a basic prior knowledge but some were not interested or had not received prior training
Makrakis et al. [27]	2021	Egypt, Jordan, Greece, Italy, and Cyprus	Curriculum design	Develop and implement a Master of Science program focused on Climate Change, Sustainable Agriculture, and Food Security in Egypt and Jordan with a focus on regional needs and challenges	The study highlights the importance of interdisciplinary approaches and stakeholder involvement in curriculum design
Oluwasusi et al. [28]	2021	Nigeria	Survey	Examine the utilization of e-learning by agricultural students in public higher institutions	The study shows low usage of e-learning among students. This is attributed to factors such as low awareness, knowledge level, technological complexity, and inadequate e-learning infrastructure.
Lourenço et al. [29]*	2021	Greece, Italy, and Portugal	Survey / Curriculum design	Identify the training and learning needs for developing a Master of Science program	Important topics to include in the programme are mostly related to crop and animal production and management, whereas future trends include efficient management of waste, and efficient resource use in crops and animal production
Baptista et al. [30]*	2021	Greece, Italy, and Portugal	Survey / Curriculum design	Identify best practices, competences, and sustainable agricultural practices to be included in a Master of Science programme	Programs should focus on interdisciplinary courses related to sustainability, including precision agriculture and the circular economy. Traditional face-to-face training methods were emphasized but because of the COVID-19 pandemic, online learning methods gained importance.
Baptista et al. [31]*	2019	Greece, Italy and Portugal	Survey / Curriculum design	Identify best practices, competences, and sustainable farming practices, and training methods to be included in a Master of Science program in sustainable farming	The study presents essential sustainable agriculture practices and effective training/learning methods for study programs. It emphasized the importance of integrating practical and theoretical knowledge, with a focus on sustainable crop rotation, crop protection management, and soil management. Some respondents also highlighted the need for future ICT training.
Sitji [32]	2018	Namibia	Survey	Explore the use of pedagogical skills by teachers in agriculture education	There is need for development in the ICT skills use of agriculture teachers
Chunwijitra et al. [33]	2017	Thailand	System design	Develop a portable e-learning box to support farmers in rural areas of Thailand	The study presents a low-power mobile gateway that provides farmers access to the e-learning environment with or without access to the internet. The study results indicated effective usability and educational benefits

*Multiple articles from this research group, where the same data set was used

Rehman et al. [23], and Woods et al. [46] provided reviews analyses of sustainable agricultural practices and education technologies.

V. DISCUSSION AND CONCLUSION

This paper presented a scoping review of e-learning in regenerative farming and sustainable agriculture. After a conducting a systematic search protocol, we were left 25 original papers describing research and development in

this field. Towards the time of writing (early 2024), it is clear that the research topic is gaining more traction.

To answer the research question *to what extent is e-learning present in the domain of regenerative farming and sustainable agriculture education??* There exist some studies which discuss e-learning explicitly in sustainable farming (for example, Abdon et al 2008 [43], Alexandrescu et al. 2010 [40], Rajendram et al. 2013 [37], and Chunwijitra et al. 2017 [33]). However, it seems that the field of research is still in its infancy. Many

TABLE II
SUMMARY OF STUDIES ON DIGITAL EDUCATION IN REGENERATIVE AND SUSTAINABLE AGRICULTURE BETWEEN 2001 AND 2016

Author(s)	Year	Country	Study Type	Objective	Key Findings
Mangir et al. [34]	2016	Malaysia	Conceptual Framework Development	Develop a framework for understanding e-learning acceptance among agricultural extension agents in Malaysia, focusing on the influence of psychological, social, management, and training factors	The article discusses various factors influencing acceptance of e-learning but does not provide empirical findings
Guiné et al. [35]	2015	Europe	Survey	Gather information for developing guidelines for online training in organic farming	Few farmers have had experience with online learning albeit many of the respondents show interest.
García-Barriocanal et al. [36]	2013	Spain	System design	Develop a knowledge modeling approach for annotating sustainable agriculture online learning resources with semantic metadata	The article reports on the successful development of an ontology model for annotating learning resources in sustainable agriculture
Rajendram et al. [37]	2013	Cambodia	System design	Develop an e-learning solution for educating students on good agricultural practices	The study's main contributions are in the developed systems and learning material but their effectiveness is not evaluated
Funabashi [38]	2013	Japan	Descriptive	the use of databases and web-based tools, in enhancing sustainable agriculture practices	The effective use of a database system and data curation promotes sharing knowledge about biodiversity
Cory-Watson [39]	2013	USA	Curriculum design / Interviews	Create a guide for educational programs about farm sustainability	The study identified content areas, tools, and approaches in sustainable agriculture education, and created the PEAS ("Programming for Education in Agriculture and Sustainability") tool for navigating the areas within them
Alexandrescu et al. [40]	2010	Romania	Curriculum design	Development and application of e-learning methodologies	The article provides a curriculum for ecological agriculture
Menalled et al. [41]	2009	Great Plains (USA)	Survey	Assess needs, knowledge, and interests of agricultural professionals likely to join an online course in sustainable agriculture	The knowledge base of agricultural professionals who are likely to join agriculture education programmes online is already strong. Curriculum design should take advantage of the participants strong prior knowledge
Herdon et al. [42]	2009	Hungary	Descriptive	Discuss the advantages of open-source based e-learning tools in agricultural education	The article describes the utility of the Moodle LMS in agriculture education. Additionally, extended tools compatible with Moodle are shown
Abdon et al. [43]	2008	Developing countries	Descriptive	Sharing experiences and challenges encountered e-learning for agriculture, and propose ways to enhance its adoption	The article details challenges in eLearning adoption, including digital divide issues, online course support and facilitation, and public support for e-learning initiatives in agriculture
Abdon & Raab [44]	2005	Asia-Pacific	Descriptive	Discuss the role of the Internet in knowledge sharing and distance learning for sustainable agriculture	Agriculture has become a knowledge-intensive industry. ICT and communications technologies play an ever-increasing role
Lieblein et al. [45]	2005	Nordic countries	Descriptive / Curriculum design	Evaluate the use of Kolb's learning cycle as a tool for designing and running an online course in Agroecology	The article presents positive student feedback from the course. Additionally, the challenges and benefits of teacher collaboration across different countries are highlighted.
Woods et al. [46]	2003	Greater Mekong Subregion	Descriptive	Discuss the development and application of web-based simulations for agricultural education.	The article does not provide empirical evidence but concludes that simulations can play a significant role in spreading sustainable agriculture knowledge
Raab et al. [47]	2001	Asia Pacific	Descriptive	Explore the potential of e-learning through multisectoral partnerships for improving human capital in the region	E-learning enables more learning opportunities, thus making education more equal and accessible.

curriculum designs are presented in the extant literature (see studies by Lieblein et al. [45], Alexandrescu et al. [40], Cory-Watson [39], Baptista and Lourenço et al. [31], [30], [29], and Makrakis et al. [27]) but few initiatives have been made to evaluate them. Thus, more efforts are recommended in this area.

The scope and limitations of the current study warrant some discussion. Since the current study is authored by one person only, we must concede that researcher bias is possible. Additionally, article searches are dependant on the databases available to the author. However, as the search protocol is described in full detail, the results

should be easily reproducible by other researchers.

Another limitation that should be acknowledged is due to the chosen research method. Scoping reviews do not (necessarily) aim to be exhaustive. Thus, this study was (intentionally) limited to finding and summarizing relevant existing studies.

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