A Systematic Review on Agriculture Gamification for Climate Change

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*Abstract –*The current climate change conditions create the need to modify agricultural technology, techniques, tools, and methods. With the growth of imminent technology and world modernization, the 21st century faces a threat to agriculture. Gamification practices are adaptable to engage user involvement and bring user satisfaction. Gamification integrated with technology quickly makes it accessible and available for users that can match the user's needs and preferred goals. Several existing studies have been added to the literature, making it relevant in marketing, e-commerce, and education. This study primarily uses systematic reviews for (Prisma) to explore the effectiveness and contribution of the existing literature through gamification in the agriculture field. The analysis of this study indicates that agricultural practices could quickly adapt to the gamification methods. However, the current state is very limited to the study area, and therefore, future studies can enable gamification, leading to the significant driving of agricultural methods. The challenge of achieving sustainable development goals remains uncertain in the current era, and gamification can facilitate its emerging need and address those gaps. The result opens future research areas to advance with upcoming challenges and new directions to the opportunities as it contributes to the gamified agriculture approach.

1. Introduction

Several factors, such as climate conditions, water, soil, livestock, and other similar resources, are essential for agriculture growth. Suitable temperatures and weather at the right time are required to generate crops in different regions. Any impact on its chain disturbs the whole natural generation process and makes it challenging to grow in a natural state [1]. Although crop rotation is also part of the process, the cleaning process of farmland adds to the other carbon emissions factors. The agricultural balance faces significant challenges because of climate change and human activities impacting the surroundings. The agricultural industry is encouraged to identify diverse problem-solving techniques. It is one of the most significant sectors since it provides daily wages to billions of workers. The agriculture sector contributes by offering food, several job opportunities, and economic growth in the global economy, with a world population growth of more than eight billion people and growing. As per the reports, the agriculture sector globally adds up to four percent to the gross domestic product (GDP), and its contribution can grow to twenty-five percent in developing economies [2].

Many emerging technologies, such as software, hardware, web-based applications, and mobile apps, are leading the agriculture 4.0 sector. Different stakeholders currently use several technology-inbuilt products for agricultural purposes and productivity. Regenerative agriculture is about securing the soil to avoid erosion and finding better ways to retain water, which will reform the soil's health and contribute to growing biodiversity. With such an approach, the result could benefit everyone in the form of soil's ability to produce better quality and nutrient-rich food and demonstrate the potential of farming. In literature, this concept is popular under another name, carbon farming, as it encourages carbon storage in the form of plants rather than release in the environment.

The field of agronomy primarily deals with developing soil arrangements to enable better production of field crops. Agronomy covers the basic human requirements through crops such as wheat, rice, and corn. Nutrients reaching the crop are essential to strengthen the food quality dependent on the soil.

Climate conditions are drastically changing due to rapid demand and global situations. It interlinks with the agricultural requirements and can impact its related elements. The transportation process of moving agricultural goods or food products requires fossil fuel consumption, another source of carbon emissions. Agriculture also requires a vast water supply, consuming nearly seventy percent of freshwater needed for its growth and production. Considering the climate change conditions and water shortages caused by unpredictable weather changes impacting agriculture, the global rise of carbon emissions and greenhouse gas emissions all result in increased pollution, which is also the primary source of agricultural impact. The researchers have highlighted climate change's impact on future generations while changing stressful situations [3]. In December 2023, more than one hundred thirty nations recently collaborated to discuss global climate change and agriculture challenges in the COP28 event arranged in Dubai.

The United Nations (UN) summarized and reported that approximately one-third of food gets wasted globally. Food waste evolves from production to the last consumption stage, and thus, it has multiple stages, such as transportation storage. Since food production goes through different phases, nearly thirteen percent gets wasted between the harvest and retail phases. Food services and households contribute about seventeen percent of total waste from the retail industry. After land restoration for agricultural activities, the existing carbon content gets automatically distributed to the environment. Also, agriculture-related tasks can release about 3.5 billion metric tons of carbon elements. The livestock used for agricultural purposes also contributed to about sixty-five percent of harmful gas emissions, such as methane. As a result, more than twenty percent of carbon content gets added because of food and agricultural-related activities.

As per the United Nations (UN) definition, agricultural sector sustainability refers to social and environmental responsibility and economic growth. The sustainable development goal (SDG) 2 is designed to focus on agriculture-related action and needs to ensure nutritious food availability and sustainability [4]. Better management of agricultural activities and operations can result in sustainability, saving the habitats required in its cycle [5].

The imminent need is to address the agricultural needs and sustainability challenges for future generations as the global population expands [6]. Therefore, the agricultural workforce's well-being is equally important to sustain this industry as climate conditions impact them and their productivity. All these aspects connect the dots of sustainability in agriculture, and continuous efforts are required to maintain the balance and follow the best practices. The UN refers to the sustainable development goals of 13 and 2 for climate action and zero hunger. The agricultural farms produce the natural food supply depending on the weather conditions, where the current climate is not sustainable for agriculture [7]. Thus, actions are required to reduce and handle the climate-related impact, and a more comprehensive range of solutions is needed.

The world of gamification is quite elaborate in its design principles with different game elements, which can be considered the non-game mode [8]. There are several mechanisms of gamification, such as rewards, levels, or stories [9]. They all aim to drive better engagement with the applicants and encourage them to enhance engagement and improve outcomes [10]. Those can result in benefits from the gamification motives, which change the applicant's attitude and behavior. In literature, the gig economy with gamification has enormous potential among Indian workers, including in agriculture, where many workers' primary sources are part-time gigs [11], [12]. Gamification enhances the user experience with different motivation levels at internal and external levels [13]. The gamification market is rising in educational purposes, marketing, and healthcare [14]. The prime agenda is to explore the gamification approach in agriculture that can contribute to the ongoing challenges in this study. This study has seven research inquiries, and the technique will be a systematic literature review.

Research Questions

RQ1 - How did the publications emerge for gamification in agriculture to understand the constructive outcome and impact of citations?

RQ2 – Who are leading journal contributors with their impactful exploration in research?

RQ3 – What are all the countries that are making an impact?

RQ4 – Who are leading author contributors with their impactful exploration in research?

RQ5 – What are the industry areas in agriculture gamification?

RQ6 – What functional usages are in agriculture gamification?

RQ7 – How can gamification contribute to the climate change problem in agriculture?

RQ8 – Where can gamification contribute to sustainable development in agriculture?
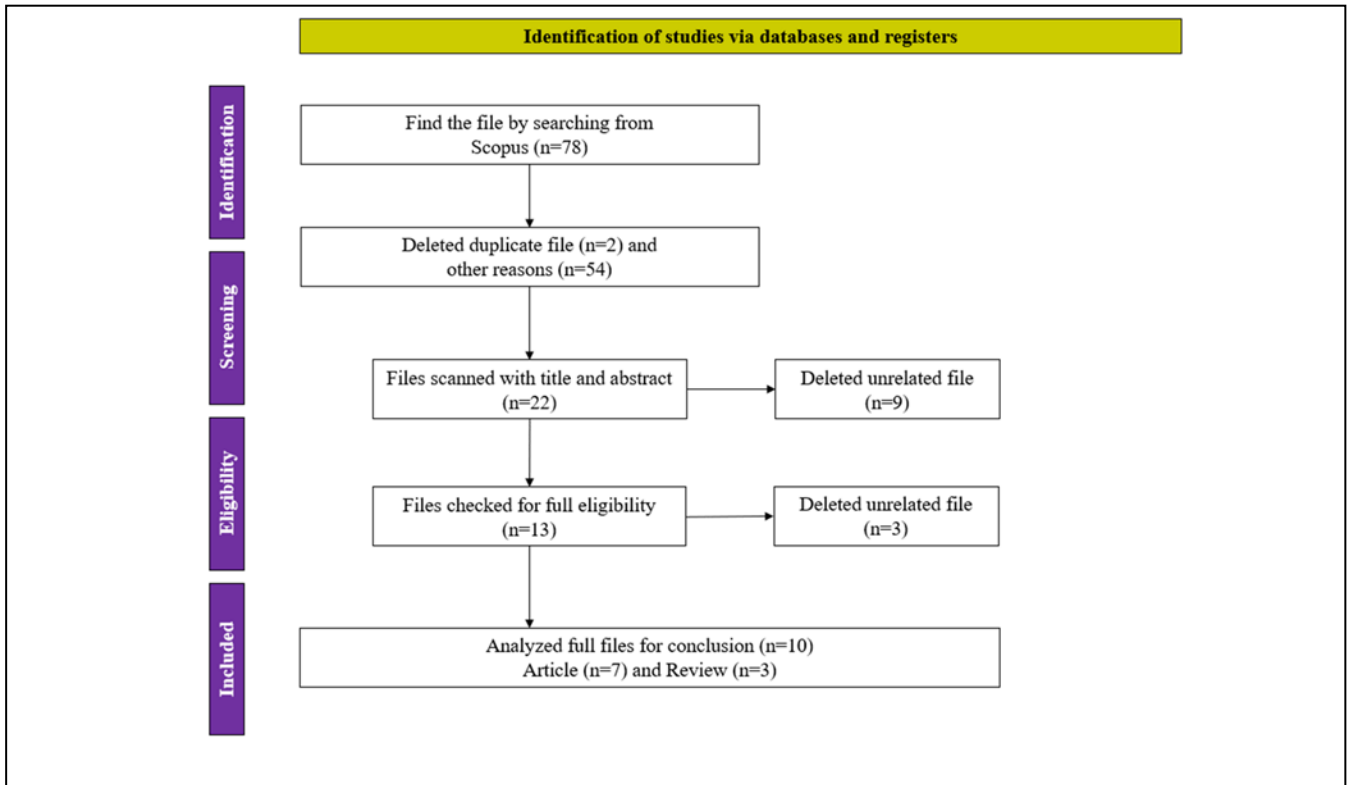
Figure 1. PRISMA - Systematic literature review

2. Materials and Methods

The research method applied in this study was Preferred Reporting Items for Systematic Reviews and Meta-Analysis (Prisma), one of the standard approaches the researchers accept [15]. It allows the author to demonstrate the quality of the study by following a structured approach to conduct the research, which is step by step. Figure 1 explains the steps included in this study. A search query identified the required files since gamification and agriculture are quite elaborate topics. The search query applied for the analysis was "(gamification OR gamic OR gamify) AND (agricultural OR agriculture OR farming OR soil or livestock)." The research index database was Scopus, which maintains a database of high-quality articles internationally.

This database has held the immense quality of scientific research since the 19th century, it covers wide-ranging areas and is comprehensive. Therefore, the information inside is diverse and covers global perspectives and publications. The query resulted in 78 files from the start till June 2023; the last search was at the end of Nov 2023. Based on the analysis, 56 files were eligible for removal because two were duplicates and the other 54 for other reasons. The other reason for inclusion is the language, English, where the record type is article or review and open access file for later analysis. The analysis resulted in a total of 22 files passed to check the title and abstract, of which nine did not meet the criteria. In total, 13 files were eligible for detailed analysis, and the other three were not. Lastly, the author considered and analyzed ten files in detail; seven were articles, and the rest were review publications.
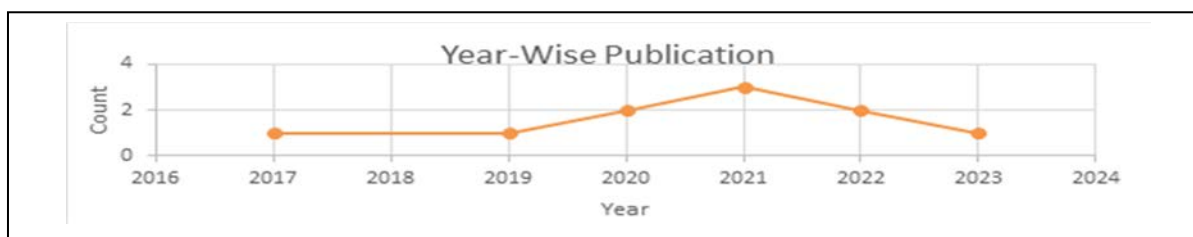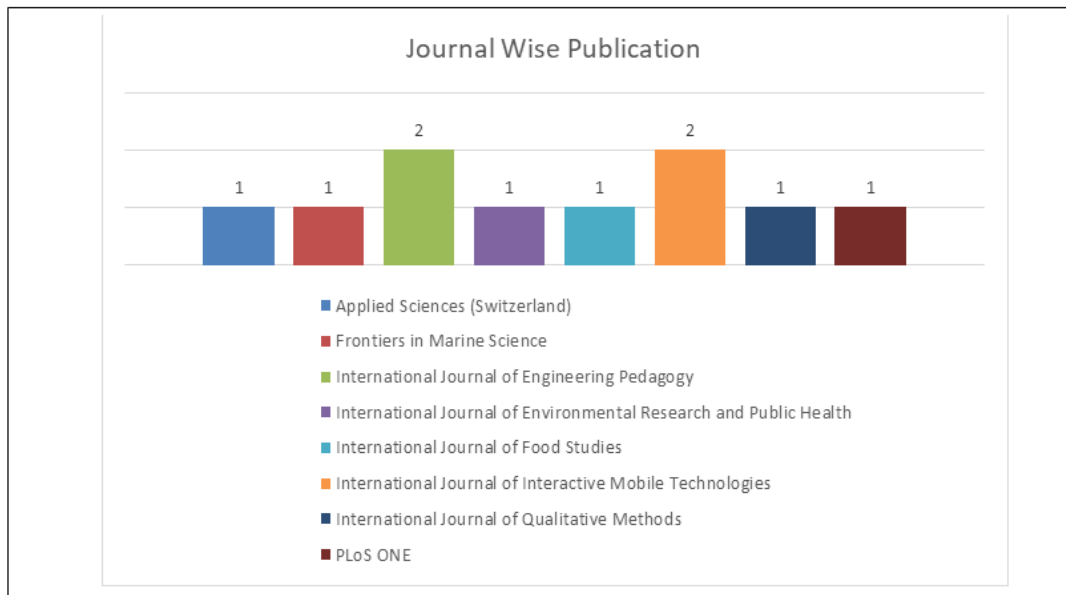

Figure 2. Year-wise publications

Figure 3. Journal-wise publications

3. Results

While searching the Scopus, the author had no duration limits to explore the maximum scope. Thus, the time frame for this study was till the end of November 2023, and after the analysis steps followed, Figure 2 details the number of publications.

The total number of records was 10, distributed among different years where 2017 and 2019 have one file each, 2020 has two files, 2021 has three files, 2022 has two files, and 2023 has one published file. Interestingly, the maximum number of publications was three in 2021, the peak of the COVID-19 pandemic, and it answers the RQ1.

Figure 4. Country-wise publications

Eight journals have published the selected scanned records, listed in Figure 3, which summarizes the scanned article's journal details. Two of the eight journals have made significant contributions, 40 percent of which are the International Journal of Engineering Pedagogy and the International Journal of Interactive Mobile Technologies. The other six journals have made each a ten percent contribution, which adds to the total 60 percent, and it answers the RQ2.

There are eight different countries where the papers are published, among which Netherlands and Spain have two papers published each, contributing to the forty percent. The other six countries publish one paper each: Australia, Belgium, Brazil, Indonesia, Italy, and Nigeria, making up the rest sixty percent. Figure 4 explains the country-wise publications made, where the leading author country gets considered for analysis, and it answers the RQ3.

Table 1. Author details

No.	Authors	FWCI Score
1	Amy E. Peden	1.887
2	Farid Dahdouh-Guebas	3.246
3	Danika Moore	0.232
4	Emiliano Soares Monteiro	0.795
5	Maria J. Poblaciones	0.135
6	Lucia Vigoroso	0.903
7	Urbano Eliécer Gómez Prada	0.302
8	Arief Rais Bahtiar	2.785
9	Adebayo Omotosho	0.887
10	Eskender Beza	3.328

Table 2. Papers that represent this study

No.	Year	Type	Refer	Functional Usage
1	2003	Article	[16]	Educational
2	2022	Article	[17]	Educational
3	2022	Article	[18]	Supply Chain Management
4	2021	Review	[19]	Supply Chain Management
5	2021	Article	[20]	Educational
6	2021	Review	[21]	Educational
7	2020	Article	[22]	Educational
8	2020	Review	[23]	Educational
9	2019	Article	[24]	Educational
10	2017	Article	[25]	Educational

Table 1 details the FWCI score of the first author listed in the Scopus, explaining the impact of field weight citation. The author who scored more than two is Eskender Beza, attaining the highest impact of 3.328. Farid Dahdouh scored 3.246, and Arief Rais scored 2.785. All the other authors have less than two FWCI scores, as listed in the table, and it answers the RQ4.

In Figure 5, two primary industry areas emerge in the study: education and supply chain management (SCM). Most papers focused on the education aspects through gamification, which accounted for eight papers. The second industry that emerges in studies is SCM, as two papers contribute to the context of agriculture's gamification, and it answers the RQ5.
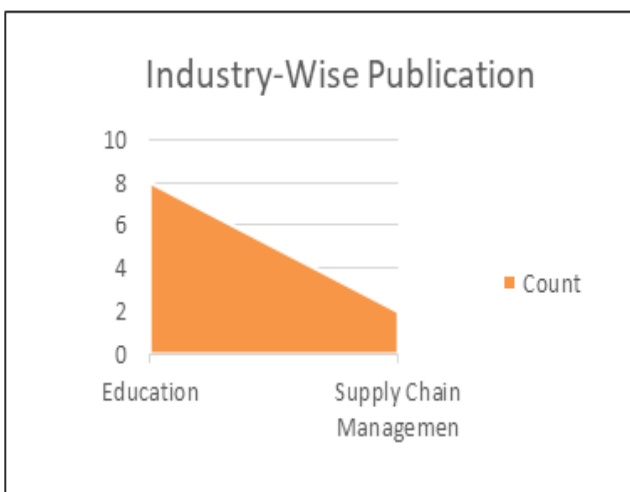

Figure 5. Industry-wise publications

Table 2 explains the list of papers finalized for this study, including all the ten articles that passed the criteria. The columns in Table 2 include the publishing year, type of file as an article or review paper, reference, and functional usage in the agriculture gamification context, and it answers the RQ6.

4. Discussion

The SCM is a prominent industry discussion topic and requires frequent adjustment with the changing demand. Several reasons for its impact, including the duration of the COVID-19 pandemic, labor shortage, interruption of supply chain, behavioral change of users, and rapid changes in demands, came as common recent issues. Therefore, the long-distance routing of food becomes a challenge in such cases, and short distances variant would be a better solution for sustainability, also known as short food supply chains (SFSCs). One of the common challenges in agriculture is making food available with the supply chain availability, as the food requires movement among many locations. Academicians proposed the GAIN model in literature as the solution-oriented model to build a firm foundation and support the different relationship levels [18]. The GAIN is a gamified approach with varying levels of engagement for better collaboration among stakeholders such as crop producers, trading partners, and financial institutions.

With the continued expansion of the global population, food requirements are growing, resulting in higher usage of agricultural chemicals. The environmental impact continued irrespective of the pandemic shutdown and instead only worsened. The author of this study proposed the APTM model, known as the Agrochemical Pervasive Traceability Model, which includes gamification and capturing information using blockchain and visual tools [19].

As a result, it tracks the reverse supply chain of chemicals by monitoring them through the Internet of Things (IoT). Gamification in this study motivates the user to participate in the whole process, which is part of the supply chain ecosystem and rewards them. The APTM model can be explored and applied to other supply chain areas to handle expensive items for wider audiences.

Youngsters injured in crop fields are pretty standard in agriculture, and the gamified approach improves education about it, making it pragmatic for schools [16]. Understanding and accepting the other stakeholders' perspectives for different purposes, such as tourism agriculture, is crucial to managing natural resources. Mangal Play is a gamified tool that supports and enables a better collaborative decision process among stakeholders in diversified roles [17]. For college students studying agricultural courses, it is vital that they feel interested and engaged in learning by using a gamification technique such as the quiz tool Kahoot [20]. Games are an excellent way to engage players and keep them interested, and the gamification of the game elements for non-game purposes can bring interest. Similarly, in agriculture, teaching the appropriate information related to security and safety will boost the users' motivation and satisfy their training and practice [21].

Agriculture includes participants from farmers, suppliers, livestock, and soil. They all become part of its ecosystem, and their productivity is critical. The gamification strategy and its elements in a simulation help farmers make better decisions and integrate with the help of information technology for maintaining and tracking the health of live socks such as cows [22]. Tourism is a common way to promote agricultural interests and boost the village's economy. Gamification supports better learning, such as for rice planting with different levels of games, and then game mechanics of rewards are given to the user [23]. Gamification can better participate in Farming-related courses to build better framing practices through the gamified prototype and, as a result, award the player to motivate the player in the form of scores or points [24]. In literature, gamification can alter intrinsic and extrinsic motivation, and agriculture farmers may have characters. Every farmer has different motives, and where such change is required to educate farmers better and encourage them to use mobile technology [25].

There are many trivial impacts because of unpredictable weather conditions, heat waves, and cyclonic or drought conditions. With such challenges, the traditional agricultural process is unproductive, which impacts different stakeholders in the cycle and is not limited to the farmers. Population growth requires food availability to rise to sixty percent in the next two centuries, which is difficult to achieve.

One solution is to change the approach and move towards intelligent methods to build resilience while complying with ongoing climate conditions. In literature, gamification mechanisms can be tailored to the target users and industry to bring value and improve outcomes. This study discusses different gamification mechanisms in agriculture, education, and supply chain management that can support the need to address sustainability. Gamification can help track fertilizers, livestock, suppliers, and stakeholders involved in agriculture procurement and other processes. As a result, it would bring more transparency to having better nutrition in food. More importantly, education on agriculture can become accessible, engaging, and enjoyable for different categories of users, with gamification resulting in engagement and motivation. The supply chain in agriculture continues to be impacted by climate change and rapidly changing demands, which require support with more innovativeness and a better engaging experience through gamification, answering RQ7. This study explains the gamified techniques to build resilience and address the need for sustainability with SDGs 2 and 13 in agriculture, answering RQ8.

5. Conclusion

The reports of 2021 reflected that nearly 27 percent of agricultural laborers hold only up to secondary education. As a result, there is an enormous, massive gap in the education required for the rest of the agricultural workforce globally. Gamification is an accessible and engaging way of learning, bringing more user attention. With accessible gamified modes and online technology, agricultural-related learning is readily available. Therefore, gamification can support addressing the rest of the associated learning needs. Gamification is evident in the education and training area in the existing literature. Also, combining emerging technologies with gamification can enhance the learning process and time required.

This study addresses the ongoing climate change and agricultural challenges to maintaining sustainability through meta-analysis by understanding gamification usage. Future studies can also test different gamification elements with users as gamification presence, acceptance, and understanding grow. As this research aimed to understand the implementation of gamification in agriculture, the study addresses the research goals with analysis. Also, future studies can capture which gamification space excites the interest of different agricultural generations.

The study concludes that there is a limited presence in agriculture from a gamification context, and therefore, future studies could be more focused on exploring different areas of agriculture. Moreover, the current literature lacks gamification studies on emerging developing countries like India, where nearly sixty-five percent of the population is in agriculture and associated activities. Future studies can also expand by conducting a gamification study among the agriculture stakeholders and workers of the gig economy.

Climate change is consistently changing, urging the agriculture sector to adopt sustainable methods with gamification. Also, the agricultural stakeholders and their workforce's productivity will be crucial in such an uncertain climate change situation, where the demand for food will only grow, and gamification can support and enhance it. This study contributes to the existing and ongoing challenges towards sustainable development in agriculture by leveraging gamification.

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