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Gamification in Agricultural Extension: A Review of Impact, Challenges, and Emerging Opportunities

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ABSTRACT

Agricultural extension is changing because the old practices are failing to maintain farmers' interest and to effect behaviour change. Gamification has been identified as a potential tool to improve communication, motivation and knowledge transfer in agriculture. This paper undertakes a systematic review, following the PRISMA 2020 protocols, to analyse the applications, impacts, and best practices related to gamification in agricultural extension. Twenty-three (23) studies published between 2017 and 2024 were analysed. The results indicate that gamification is beneficial in terms of motivation, involvement, retention, and behavioural modification, and it promotes cooperation and collaborative learning. Both the digital and analogue methods prove to be effective, but their application in the developed and developing regions differs. Best practices identified include customising interventions to the needs of the audience, incorporating experiential and participatory design, making them accessible with the help of low-cost tools, and aligning gamification with the sustainability objectives. The review comes to a conclusion that gamification is a context-sensitive and flexible tool that can be used to reinforce agricultural extension and further the cause of sustainable agricultural practices. It recommends policy makers and extension practitioners to use a blended digital and analogue gamification approach that is context-specific to the realities on the ground to optimise inclusiveness and effectiveness. The contribution of this paper is that it synthesises evidence systematically across high- and low-technology strategies, and suggests a detailed model of integrating gamification into agricultural extension.

1. Introduction

Agricultural extension is a key component in ensuring sustainable agricultural development, as farmers can gain knowledge, learn new practices, and increase productivity through the extension services (Hameed & Sawicka, 2023; Inutan et al., 2025; Raidimi & Kabiti, 2019). Conventional extension practices like radio broadcasts, printed pamphlets, and field demonstrations have shown a weak performance in reaching out to the different farming communities, particularly the younger generation and the smallholder farmers in rural settings (Musinguzi et al., 2024; Kassem et al., 2019; Hammas et al., 2024; Sennuga & Fadiji, 2020). Conventional methods tend to fade and cannot be used to convert knowledge into lasting behavioural change (Blum et al., 2020; Davis, K., & Sulaiman, 2014). Consequently, there are increased efforts to seek more interactive and participatory strategies to enhance agricultural

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communication and farmer participation. Gamification, which is understood as the application of game design principles to non-gaming applications in general, is one of them (Hamari, 2019). Gamification is an approach to applying game design elements strategically to non-game activities, typically by using point systems, badges, leaderboards, challenges, and feedback mechanisms (Koivisto & Hamari, 2019; Klock et al., 2020). As an example, reward points can be used in a farmer training session as a way of rewarding participation or role-playing aspects of pest management games without necessarily needing a fully realised game environment.

The concepts of gamification and serious games are often confused in the literature, but they represent different concepts. Gamification is the use of game design mechanics (e.g., points, badges, leaderboards) in non-game systems to increase motivation and engagement (Larson, 2020; Zadeja & Bushati, 2022; Oliveira & Petersen, 2014). It works by capitalising on the psychological tendency of humans to interact with game-like mechanics to make otherwise boring activities more interesting (Larson, 2020; Tinç & Karadayı, 2020).

By contrast, serious games refer to fully developed games that have been developed with a clear educational or functional objective beyond entertainment (Tinç & Karadayı, 2020; Warsinsky et al., 2021). Differing from gamification, where game elements are incorporated in pre-existing tasks, serious games encompass learning goals in the gameplay process, thus making the game the main instructional or training tool (Warsinsky et al., 2021). Serious games are developed to serve as stand-alone, immersive learning activities (e.g. simulations of entire farm ecosystems), whereas gamification involves the introduction of game-like incentives to an existing process or communication strategy. A recent systematic review of serious games in agriculture shows how they are unique in simulating complex agro-ecological systems (Dernat et al., 2025). Conversely, gamification is aimed at the improvement of motivation, engagement, and learning in an already set extension or education structure (Oliveira & Petersen, 2014).

Hamari (2019) states that the essence of gamification is the ability to generate an experience that is engaging enough to motivate users to participate in it via playful and interactive processes. Likewise, Nuritha et al. (2017) highlight the importance of gamification as a new concept that is based on game mechanics and social computing, which are meant to impact the adoption and interaction of the user. Even more so, this view is supported by the fact that gamification is not only about entertainment, as Johnson et al. (2016) and Seaborn and Fels (2015) point out, but it is deliberately used to influence user behaviours and enhance results through design-based interventions. Gamification is the use of game design principles in non-game applications to improve user engagement, retention and interaction (Robson et al., 2016; Kara & Russell, 2024; Khoshkangini et al., 2021).

Gamification makes an otherwise routine or complicated task an interesting experience by incorporating mechanics of goal setting, instant feedback, social reinforcement, and narrative immersion (Alsawaier, 2018; Sailer et al., 2017; Mekler et al., 2013).

The concept of gamification is proving to be a potential strategy to facilitate engagement, motivation, and knowledge transfer in the agrarian and agricultural extension sector. Gamification can assist in making agricultural training more attractive, especially to the younger generation, who could be losing interest in pursuing an agricultural career, by including game elements, like challenges, rewards, and

feedback loops (Kovacs et al., 2021). Gamification has been successfully applied in vocational and higher education to educate students on sustainable agricultural practices, aid in the rebuilding of the agricultural workforce, and promote pro-environment behaviours (Ramadhan & Junus, 2024; Santos-Villalba et al., 2020).

In addition to formal learning, gamification helps to promote communal learning and farmer-policymaker cooperation by conceiving agricultural extension as a participatory competition, which enhances both learning by doing and peer-to-peer learning (Burbach et al., 2024). Studies support the idea that gamification can be an indispensable element of climate-smart agriculture and adaptation plans due to the active participation of farmers and the promotion of the availability of sustainable practices (Tayal & Rajagopal, 2024). Besides, the examples of agricultural marketing reveal how a gamified approach can assist small producers to survive market shocks and build consumer loyalty (Koleva, 2021). Gamification can also be used to create immersive simulations of agricultural training and skill acquisition as digital technologies such as virtual reality and AI continue to grow (Strousopoulos et al., 2023).

These demonstrate that gamification is not only a rich learning experience, but also develops the capacity towards sustainable agriculture in terms of behaviour change, facilitating farmer cooperation, and enhancing knowledge sharing within extension systems. There is increased interest in gamification in the agricultural sector, especially with the rapid proliferation of mobile and digital platforms in the rural population. Gamification does not, however, have to be restricted to digital interventions. Farmer competitions, participatory field trials, role-play activities, and other analogue processes can be gamified as well (Nicolas et al., 2020). Such a duality contributes to gamification being a flexible tool in both high-tech and low-tech situations.

Even though gamification has been extensively researched in education, business, and sustainability, conclusions on the use of gamification in agricultural extension are limited. The available reviews of gamification in education indicate that implementing gaming elements without an understanding of institutional conditions or the backgrounds of learners is likely to fail (Ofosu-Ampong, 2020). Other research on gamification has focused on its potential to fail behavioural change and promote sustainable development goals, although these tend to look at more general areas of sustainability or technology acceptance, rather than specifically in agriculture (Tayal & Rajagopal, 2024). Studies often confuse gamification with serious games, making it challenging to isolate the unique role of gamification (Dernat et al., 2025).

Research in this area has been skewed towards education (Mustafa et al., 2022; Ab Rahman et al., 2019; Garc a et al., 2021) and has largely left out the agricultural perspectives. Available reviews tend to lack methodical methods (e.g., PRISMA), which results in variations in the synthesis of evidence (Ofosu-Ampong & Anning-Dorson, 2020).

Most of the existing studies focus on high-tech gamification (VR, AI, mobile apps), leaving low-tech or analogue gamification that can be more accessible and scalable in low-resource farming communities (Tayal & Rajagopal, 2024). This paper fills these gaps by performing a PRISMA-based systematic review of gamification in agricultural extension. Specifically, the study identifies and examines uses of gamification in agricultural extension, ii. assesses the effects of gamification on knowledge retention,

adoption of practices, and behavioural change, and iii. synthesises good practices, including both digital and non-digital methods, to guide policy and practice in agricultural development communication.

This paper, in contrast to previous studies, differentiates gamification and serious games, uses strict inclusion and exclusion criteria in several databases and synthesises the evidence on digital and analogue gamification techniques. By such a contribution, the study will offer policymakers, practitioners of extension, and researchers' practical information on how gamification can be used to enhance agricultural extension communication in various settings.

2. Methodology

2.1. Protocol and framework

This paper was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) (Page et al., 2021). PRISMA provides systematic, transparent and reproducible steps in the selection of literature, thus minimising selection bias and increasing validity. To depict how the studies were identified, screened, determined as eligible, and included, a PRISMA flow diagram (Fig. 1) was created.

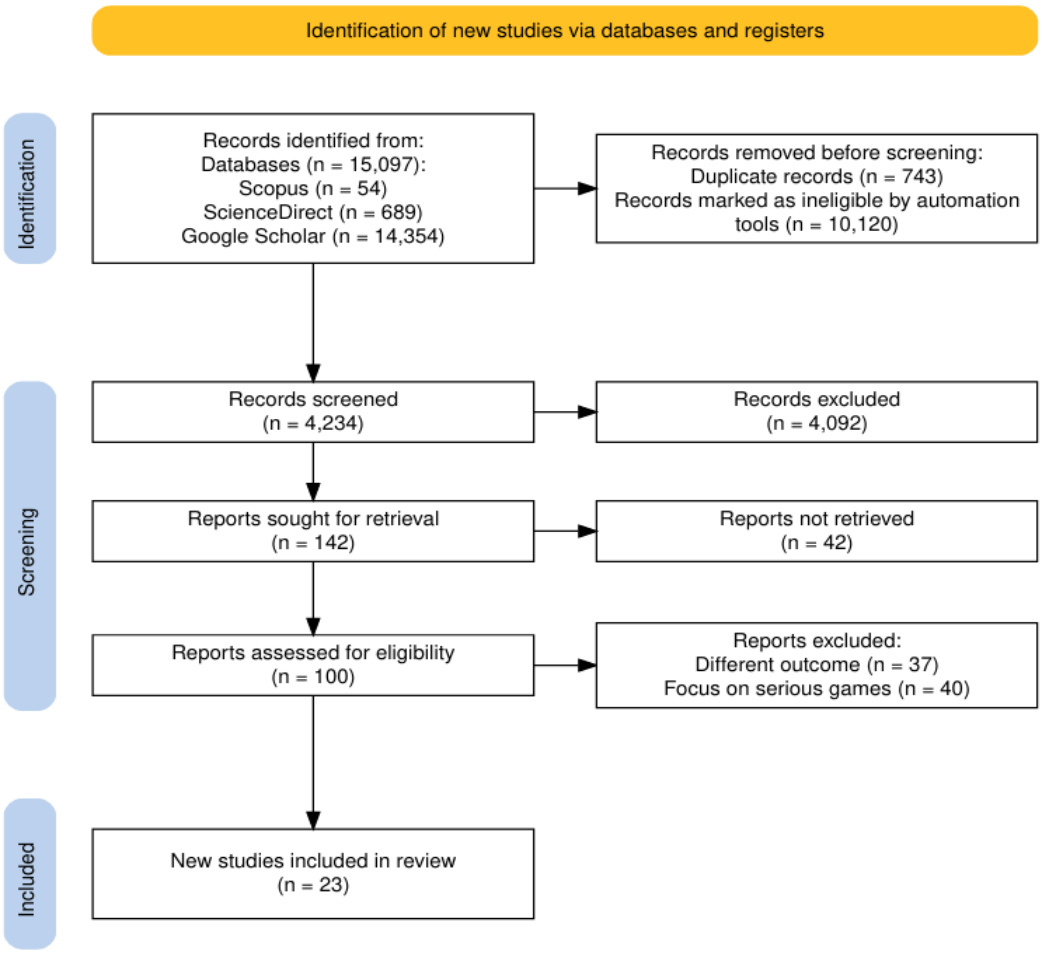

Figure 1. PRISMA flow diagram depicting the study selection process for the review

Source: Own author research

2.2 Databases and search strategy

The search of the literature was conducted in three databases, Scopus, ScienceDirect, and Google Scholar, between March and July 2025. Scopus was chosen because it is the internationally recognised indexing platform of peer-reviewed, multidisciplinary scholarship. ScienceDirect was also added due to its extensive coverage of agricultural and technological research. Google Scholar was included as a secondary source to retrieve recent, cross-disciplinary or open-access research which is not yet indexed on the major databases. A combination of keywords and Boolean operators was used, including gamification AND agriculture, gamification AND agricultural extension, farmer training AND gamification, and low-tech gamification agriculture. The search strings for each database are found in the supplementary material.

2.3 Inclusion and exclusion criteria

Studies were considered when they were peer-reviewed, written in English, and specifically addressed gamification as applied to agricultural extension, training, or communication. Empirical studies that have measurable results like changes in knowledge retention, behavioural change or adoption of practices were considered. Digital gamification (e.g. apps, virtual reality) and analogue gamification (e.g. competitions, role-play, reward systems) were both taken into consideration. Articles published in 2017-2025 were taken into account. Articles were omitted in case they concentrated only on serious games, or were non-empirical, non-agricultural, written in a non-English language, or non-methodologically rigorous. The review also excluded grey literature, including any opinion pieces and unpublished reports, in order to uphold the scholarly standard of the review.

2.4 Study selection process

The search returned 15097 records in the three databases. Upon elimination of 743 duplicates, titles and abstracts were screened, and 14354 articles were discarded because they were irrelevant to gamification in agriculture. One hundred and forty-two (142) full-text articles were screened. Among them, 119 were discarded due to their exclusive focus on serious games and lack of empirical evidence. The total review consisted of 23 studies. Three reviewers independently carried out screening, and disagreements were resolved by discussion.

2.5 Data extraction and synthesis

To create uniformity, a structured data extraction template was created. In each of the studies, the data on the author(s), year of publication, country or region, target audience, and reported outcomes were recorded. This was followed by a thematic synthesis method whereby the results were organised into three broad themes of applications of gamification, the effects on learning and behaviour in agriculture, and best practices.

3. Results

3.1. Overview of included studies

The systematic review involved 23 studies published from 2017 to 2024. The findings depict a developing body of work on gamification in the context of agriculture. The studies were spread across geographical areas with Europe (Hungary, Italy, Spain, Belarus, France), Asia (China, India, Singapore),

Africa (Nigeria, Ghana), and North America (United States, Canada) being represented. This allocation is a sign that the world understands the possible contribution of gamification in agricultural growth and learning. The audiences of the reviewed studies were diverse, such as farmers and extension workers (Koleva, 2021; Tayal & Rajagopal, 2024), university students and vocational trainees (Kovacs et al., 2021; Omotosho et al., 2019; Efremova, 2023), agro-industrial employees (Andreenko, 2024; Vigoroso et al., 2021), and agricultural consumers and stakeholders in marketing. Taken together, the evidence illustrates that gamification in agriculture has a multidimensional character, not only in terms of educational outcomes but also in terms of the productivity of the workforce in agriculture, marketing and participatory research. An overview of the studies included is provided in Table 1.

Table 1. Characteristics of reviewed studies

Author(s), Year	Country/ Region	Target Audience	Objective	Key Outcomes
Hamari, 2019	Global	Researchers, educators	Explain gamification	Defines gamification as a popularly used term of description, as the application of game elements within non-game situations
Koleva, 2021	Eastern Europe	Farmers	Improve enthusiasm	Gamification increases youth farmer engagement
Tayal & Rajagopal, 2024	India	Farmers, extension workers	Build awareness of climate-smart agriculture	Gamification is effective in changing farmers' perception of climate risks.
Ofosu-Ampong & Anning-Dorson, 2020	Africa	Developing country farmers	Identify adoption barriers	Highlights low-tech gamification potential in rural areas.
Burbach et al., 2024	USA	Natural resource managers	Strengthen collaboration in natural resource management	Enhanced joint problem-solving and trust-building.
Lombardelli et al., 2020	Argentina	Farmers, robotics trainees	Support Good Agricultural Practices	Increased learning engagement and knowledge sharing.
Ju et al., 2024	China	Harvesting workers	Improve harvesting efficiency	Gamification improved worker motivation and efficiency.
Markopoulos et al., 2019	Asia	Rice industry stakeholders	Raise awareness of the rice supply chain	Increased collaboration and sustainability awareness.
Kovács et al., 2021	Hungary	Agriculture students	Teach sustainability in agriculture	Boosted student motivation and sustainability knowledge.
Efremova, 2023	Russia	Agriculture trainees	Prepare agricultural specialists	Gamified tasks improved skill acquisition.
Omotosho et al., 2019	Nigeria	Agriculture students	Increase farm practice participation	Increased student engagement and practice hours.
Martin et al., 2018	Spain	Farmers, researchers	Support participatory knowledge	Promotion of knowledge co-creation

Author(s), Year	Country/ Region	Target Audience	Objective	Key Outcomes
Strousopoulos et al., 2023	Greece	Beekeepers	Teach apiculture	Improved knowledge acquisition and retention
Jaiswal et al., 2021	Finland	Farmers, machinery buyers	Encourage the use of machinery	Interactive learning enhanced purchase intentions
Andreenko, 2024	Belarus	Agro-industrial workers	Motivate workforce	Enhanced morale and efficiency.
Vigoroso et al., 2021	Italy	Agriculture workers	Enhance work safety	Safety knowledge and compliance improved with gamification.
Abed et al., 2018	France	Students, engineers	Study the gamification-serious game overlap	Demonstrated value of gamified training modules.
Chandross & DeCourcy, 2018	Canada	Online learners	Boost engagement in online courses	Increased motivation in distance learning.
Sailer et al., 2017	Germany	University students	Study motivation	PBL satisfied autonomy, competence, and relatedness.
Sundareswaran et al., 2024	India	Medical students	Teach physiology to Gen Z	Gamification improved recall and interest.
Pavlenko et al., 2021	Europe	Farmers	Encourage adoption	Increased adoption readiness.
Hamari et al., 2023	Hawaii	Researchers, practitioners	Present updated gamification research trends and applications	Consolidates state-of-the-art knowledge, showing gamification's growth across education, health, and business domains.
Ju et al., 2024	China	Agriculture workers	Increase productivity	Higher efficiency & job satisfaction.

Source: Own author research

3.2 Applications of Gamification

Table 2 outlines areas of use of gamification. It has mainly been utilised in agricultural extension to enrich farmer participation and involvement in training programs. As an example, Koleva (2021) and Tayal and Rajagopal (2024) illustrated how gamified interventions encouraged farmers to participate in extension activities and developed a cognisance regarding climate-smart agriculture. On the same note, citizen science projects that were implemented based on the works by Martin et al. (2018) and Burbach et al. (2024) had game elements incorporated to drive farmers and researchers to work together, share knowledge, and develop solutions together. Schools have also turned out to be one of the major places to gamify. Higher education and vocational research (Kovacs et al., 2021; Omotosho et al., 2019; Efremova, 2023) confirmed that gamified classrooms or mobile aids were used to enhance student engagement, promote more active learning in the field and better acquire skills. In their more advanced application, Jouan et al. (2020) and Strousopoulos et al. (2023) combined role-play and training in virtual reality (VR) to immerse practitioners and students in the field of agroecology and apiculture, proving that experiential learning can be gamified. Gamification has also been used in the agricultural workforce and industry. Andreenko (2024) and Vigoroso et al. (2021) considered gamified safety and incentive-based training of agro-industrial workers and revealed the positive changes in morale, knowledge, and

compliance. At the company level, the study by Jaiswal et al. (2021) demonstrated how gamification of marketing activities led to an increase in the adoption of agricultural machinery, whereas Pavlenko et al. (2021) described farming simulation games as a tool to foster adoption of precision agriculture. The combination of these findings indicates that gamification in agriculture is more than just learning, but it also encompasses behavioural change, workforce development and the adoption of technologies.

Table 2. Uses and effects of gamification in agricultural extension

Area of Use	Source	Influence
Motivation and involvement of farmers	Koleva (2021); Tayal & Rajagopal (2024)	Increased involvement in extension programs and knowledge of climate-smart agricultural practices
Citizen science and participatory extension	Martin et al. (2018); Burbach et al. (2024)	Improved knowledge sharing, stronger community engagement and collaboration between farmers and researchers
Agricultural education (universities and colleges)	Kovács et al. (2021); Omotosho et al. (2019); Efremova (2023)	Increased student motivation, improved sustainable learning, and better skill training in agricultural education
Vocational and technical training	Strousopoulos et al. (2023)	Increased learning efficiency; systemic agroecological thinking; better problem solving
Occupational safety and training of the workforce	Andreenko (2024); Vigoroso et al. (2021)	Better worker morale and productivity; better occupational safety practices
Accurate farming and the use of technology	Pavlenko et al. (2021)	Greater willingness to embrace precision agriculture and new technologies
Agricultural marketing and trade	Jaiswal et al. (2021)	Stronger customer engagement; improved adoption intentions for agricultural machinery

Source: Own author research

3.3 Application of gamification in developed and developing Countries

Gamification in agricultural extension has shown a significant regional variation between the developed and developing nations. Gamification has largely been applied as a low-cost method of enhancing the motivation and involvement of farmers in agricultural extension activities in developing countries. In Ghana, studies emphasised that low-tech gamification methods like point systems, role-play and competitions could be applied even to communities with limited access to digital technologies (Ofosu-Ampong & Anning-Dorson, 2020). In India, gamification was employed to create awareness of climate-smart agriculture practices with the focus on behavioural change and not technological superiority (Tayal & Rajagopal, 2024). In China, gamified workplace interventions were implemented on harvesting activities, and it proved that gamification could be another motivation factor in the work of agricultural labourers in labour-intensive settings (Ju et al., 2024). Likewise, Sub-Saharan African studies point to gamified mobile learning as a solution to address the issue of literacy and engagement among young

people in agriculture, where conventional extension methods are frequently not able to generate long-term interest (Omotosho et al., 2019). These examples show that, in developing countries, more frequently, gamification aims at stimulating awareness, engagement, and inclusion, as opposed to using sophisticated digital platforms.

In contrast, developed countries tend to combine gamification with more developed technologies and institutional structures, as they have a greater investment capacity and are more prepared to go digital. In Europe, gamified methods are more integrated into agricultural higher education to overcome the dropping student interest in agriculture and enhance sustainability education and professional skills (Kovacs et al., 2021; Efremova, 2023). In addition to the classroom, some studies tested the use of high-tech tools, including a VR and simulation platform to train beekeepers (Strousopoulos et al., 2023) and promote the adoption of high-tech agricultural methods (Pavlenko et al., 2021). There were also European projects that integrated gamification into their collaborative citizen science platforms that could allow farmers and researchers to co-create knowledge in participatory forms (Martin et al., 2018; Burbach et al., 2024). Gamification was commonly discussed in the context of workforce and professional education in North America, as well as in collaborative decision-making, which proved its relevance in enhancing not only individual knowledge but also team-based problem-solving (Chandross & DeCourcy, 2018; Burbach et al., 2024). The concept of gamification has also been used in agricultural marketing, whereby gamified interactive platforms enhance consumer loyalty and aid small producers in their ability to respond to changing markets (Koleva, 2021). Gamification research in North America and Western Europe has also considered its application in workforce productivity and social comparison processes, showing both positive motivational potential and the risk of pressure or exclusion in case of ineffective design (Huschens et al., 2019). Such distinctions are indicative of a greater structural difference, wherein developing countries focus more on accessibility, motivation, and behavioural change via basic gamification mechanics, whereas developed countries are more concerned with integration into more advanced technologies, marketing schemes, and system-sustainability objectives. Significantly, this comparative approach highlights the necessity of context-specific best practices. Gamified tools that are high-tech might not be an option in low-resource environments, but ideas on low-cost and inclusive gamification in developing contexts can be applied in equity-based design in more affluent regions. On the other hand, VR, simulation, and digital marketing innovations in the developed countries could, when modified, provide a scalable way of modernising extension systems in the developing world.

3.4 Impacts of gamification

The evidence presented in this review indicates that gamification has several consistent effects in agricultural extension and other fields (Table 2). To begin with, gamification was highly linked to motivation and engagement among all the target groups. Farmers and students who received gamified training or learning environments demonstrated greater enthusiasm for participating in the training or learning environment compared to their traditional counterparts (Omotosho et al., 2019; Koleva, 2021; Andreenko, 2024). This inspirational impact is usually found in more regular attendance and increased retention. Second, gamification helped increase knowledge and skill acquisition. Studies on vocational training (Efremova, 2023; Strousopoulos et al., 2023) revealed that gamified modules enhanced theoretical knowledge and practical skills. On the same note, simulation-based tools (Pavlenko et al.,

2021) and agroecology role-play games (Jouan et al., 2020) enabled participants to experiment and think in a systemic way and thus enhanced their learning. Third, gamification helped to change the behaviour and embrace innovations. Specifically, gamified simulations encouraged farmers to be willing to implement precision agriculture technologies (Pavlenko et al., 2021) and created climate-smart agricultural practices awareness (Tayal & Rajagopal, 2024). This shows that gamification has the potential to go beyond engaging to affect the long-term decisions in agricultural development. Lastly, gamification encouraged participatory strategies and collaboration in extension. Martin et al. (2018) and Burbach et al. (2024) showed the potential of game mechanics to promote collaborative problem-solving and community solutions, and to support the role of extension as a mutual exchange process and not a top-down process. Simultaneously, some studies identified the following issues: the expenses of technology, accessibility difficulties in low-resource settings, and a close differentiation between gamification and serious games as a requirement to prevent a conceptual muddle (Hamari, 2019; Hamari et al., 2023). The evidence is that gamification in agricultural extension is showing quantifiable returns in motivation, learning, adoption and collaboration.

3.5 Best practices in agricultural gamification

The review identifies some best practices that can reinforce the design and implementation of gamification in the agricultural setting (Table 3). One of the key concepts that becomes apparent is that accessibility should be prioritised, particularly in resource-poor settings. Research in the developing nation has advised against the use of costly or technology-dependent platforms, as these may inadvertently leave the smallholder farmers out. Rather, low-cost and mobile-based strategies were demonstrated to be more inclusive and equally effective in maintaining engagement (Ofosu-Ampong & Anning-Dorson, 2020; Koleva, 2021). The other best practice is the adaptation of gamification to the needs and profiles of the targeted audience. The evidence of higher education shows that gamification strategies that are relevant to learners and their subject matter and culture are more likely to produce stronger, more sustainable results (Klock et al., 2020; Kovacs et al., 2021). This supports the premise that gamification cannot be a blanket approach and needs to be adapted to the specifics of the user and the realities on the ground. Also, the inclusion of participatory and collaborative aspects in gamified interventions is crucial. Research demonstrates that gamification can be most effective when it helps farmers to produce and exchange knowledge collaboratively and make decisions at the community level (Martin et al., 2018; Burbach et al., 2024). These participatory designs not only encourage individuals but also increase ownership of agricultural innovations at the community level. Gamification combined with experiential training also proved to be a strong best practice. Blended interventions combining both game mechanics and practical learning, e.g., VR-based training to teach new beekeepers or role-play games in agroecology, had more profound results in learning and more sustainable acquisition of skills than purely digital or theoretical interventions (Strousopoulos et al., 2023; Jouan et al., 2020). This is an indication that gamification works best when it is integrated into the cycles of experiential learning processes and not when it is used as a single motivating instrument. Moreover, by linking the gamification to the larger sustainability and innovation goals, one can increase the relevance and impact. The use of gamified designs in climate-smart agriculture and precision farming provided evidence that such designs are not only attractive and effective teaching tools, but also powerful mechanisms of initiating long-term behavioural change and sustainable practice adoption (Tayal & Rajagopal, 2024; Pavlenko et al., 2021). The gamification interventions can have a more extensive

impact by encompassing sustainability objectives as part of their design and, thereby, contributing to the development of the agricultural system. Lastly, best practice entails that gamification should be measured beyond the immediate engagement outcomes, like enjoyment or rate of participation. Examples of research on motivating the workforce and workplace safety demonstrate the necessity of associating gamification with real-life behavioural changes, such as skill development, increased productivity, and behavioural change (Andreenko, 2024; Vigoroso et al., 2021). This evidence is important to persuade policymakers and extension practitioners about the usefulness of gamification in agriculture.

Table 3. The Best Approaches to Gamification in Agriculture

Best approach	Illustration of Use	Motivation	Sources
Use low-cost, easily obtainable tools	Rural farmer engagement	accessibility and relevance in low-resource settings	Ofosu-Ampong & Anning-Dorson (2020); Koleva (2021)
Personalise gamification in accordance with the audience's needs	Agricultural courses in the university	Personalisation improves learning and engagement in the long run	Klock et al. (2020); Kovács et al. (2021)
Include participatory and collaborative aspects	Citizen science services and joint learning on natural resources	Promotes mutual learning, local ownership and long-term involvement	Martin et al. (2018); Burbach et al. (2024)
Combine gamification with experiential/role-based training.	Agroecology role-play (SEGAE); VR-based apiculture training	Strengthens hands-on skills and systemic problem-solving	Jouan et al. (2020); Strousopoulos et al. (2023)
Contextualise gamification with climate and sustainability objectives	Training in climate-smart agriculture in India; implementation of precision agriculture in Europe	Promotes environmental stewardship and technological innovation	Tayal & Rajagopal (2024); Pavlenko et al. (2021)
Measure adoption and productivity beyond engagement	Motivation in agroindustry: occupational safety training	Demonstrates real-world effectiveness and outcomes beyond short-term participation	Andreenko (2024); Vigoroso et al. (2021)

Source: Own author research

4. Discussion

The collected evidence indicates that gamification can be used as a motivational driver, although its effects are context-sensitive and depend on technology and culture. To start with, gamification has been proven to improve engagement and motivation of students in agricultural education, as well as in other fields. Indeed, studies conducted in Hungary showed that gamified learning environments promoted the interest of students in sustainable agricultural higher education, especially among the younger group, but the perceptions of usefulness were similar across all age groups (Kovacs et al., 2021). The

same trends are observed in elementary and rural school settings where gamification enhanced intrinsic motivation and educational outcomes, particularly when the challenges and rewards were balanced with learning objectives (Sappaile, 2024; You & Sanmugam, 2024). These results support the notion that gamification has potential in agricultural extension, where motivation and long-term engagement are essential. Second, Access to technology and the contextual adaptation are a critical limitation. Gamified interventions in rural Malaysia enhanced the competence and usefulness of the students, although poor internet connectivity and low digital literacy weakened the engagement (Sanmugam et al., 2016). Similarly, gamification in rural China allowed keeping the cultural heritage by using local game elements, but its success was based on the adjustment of tools to low-resource contexts (You & Sanmugam, 2024). This indicates that we cannot equate gamification in agricultural extension with high-tech interventions like virtual reality, but we should also include low-tech and culturally based innovations. Finally, in addition to education, gamification has been shown to have merit in employee training and workforce productivity in the agricultural sector and allied industries. Research indicates that gamified training can enhance the engagement, motivation, and knowledge retention of employees, and may be advantageous in the context of agro-industrial workers (Andreenko, 2024; Pavlovic, 2023). But all that can work only on prior levels of engagement. Gamification may not work in low-engagement settings where performance is not improved or even decreased (Buell et al., 2019). This underlines the necessity to adapt the gamification techniques to the needs and the level of readiness of the users.

Limitations and future research directions

There are a few limitations that must be considered in this study. First, the studies reviewed were widely heterogeneous in terms of methodological rigour, with many using small-scale case studies, short-term interventions, or self-reported results. These designs can exaggerate the short-term benefits of engagement without measuring long-term behaviour change, knowledge maintenance or the adoption of sustainable behaviours. The other limitation is the lack of clarity of the conceptual differences between gamification and serious games. Some of the research studies did not distinctly distinguish between these strategies, and it was not easy to determine the individual contributions of gamification in the extension situations. Lastly, the geographical focus of the majority of the studies lay in Europe, Asia and North America, with a relatively small number of examples of Sub-Saharan Africa, Latin America or other places where agricultural extension is a key development factor. The limitations identified should be addressed in future studies by following a few major directions. First, longitudinal and large-scale research is required to investigate the long-term effects of gamification on farmer behaviour, technology adoption, and productivity. Second, researchers need to explore further low-cost, analogue gamification interventions that are feasible in rural and resource-limited settings, and inclusive of smallholder farmers. Lastly, cultural and contextual adaptation should be considered more closely in future research, as the local culture, community, and socio-economic factors should be examined to determine the efficiency of gamified interventions.

5. Conclusion

This systematic review shows that gamification has the potential to transform agricultural extension in terms of increasing motivation, knowledge retention and behavioural change in various settings. The evidence demonstrates that digital and analogue gamification strategies can enhance participation, support collaboration, and encourage sustainable agricultural practices on the condition that they are

well designed to fit local technological, cultural, and socioeconomic conditions. Notably, the review brings to the fore the importance of differentiating between gamification and serious games, so as to maintain conceptual clarity in research and practice. There are best practices too, including using low-cost tools, tailoring the interventions to user needs, and integrating participatory and experiential learning elements, which also contribute to effectiveness and inclusivity. Nevertheless, there are still issues, especially in terms of access to technology, assessment beyond short-term interest and the threat of universal designs.

Practically, the study shows that gamification would be a potential strategy to use in agricultural extension to enhance engagement, motivation, and learning outcomes among various stakeholders. Training programs can include training elements like role-play and feedback mechanisms to make agricultural communication more interactive and participatory by extension agents and educators. Where digital infrastructure exists, mobile-based applications and immersive technologies such as virtual reality can be integrated, but where resources are scarce, low-tech methods such as farmer competitions, participatory field trials, and analogue reward systems are also very effective. On the policy front, the results indicate that agricultural development models should proactively incorporate gamification in contemporary extension policies. Policymakers need to encourage inclusive strategies that make the gamification interventions (both digital and analogue) accessible to smallholder farmers in low-resource environments. This involves the need to balance between investing in high-tech solutions and promoting scalable low-tech practices that can be easily introduced in rural regions. Gamification can also be integrated into the vocational curricula, professional training and farmer outreach programs offered by national agricultural institutions and extension services as one of the ways to restore interest in agriculture, especially among young people. Policy frameworks must also require a systematic assessment of gamification interventions beyond measures of enjoyment/participation, so that results are gauged in knowledge retention, productivity and the use of a sustainable practice. Lastly, the development of collaborations between universities, NGOs, the private sector and government agencies will be essential in collaboratively developing context-sensitive, culturally relevant and aligned with wider agricultural development agendas, gamification tools.

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