frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 08 January 2024
DOI 10.3389/fsufs.2023.1254261

OPEN ACCESS

EDITED BY
Bruno Jorge Antunes Colaço,
University of Trás-os-Montes and Alto Douro, Portugal

REVIEWED BY
Sofia Alves-Pimenta,
Universidade de Trás-os-Montes e Alto, Portugal
Sandra Sacoto,
University of Trás-os-Montes and Alto Douro, Portugal

*CORRESPONDENCE
Mohammed A. Elmetwally
✉ mmetwally@mans.edu.eg

RECEIVED 13 October 2023
ACCEPTED 18 December 2023
PUBLISHED 08 January 2024

CITATION
Lenis YY, Montgomery AJ, Carrillo-González DF, González-Palacio EV, Barrios D and Elmetwally MA (2024) Agricultural literacy in artificial insemination and agribusiness management for social innovation in rural populations affected by armed conflict in Colombia.
Front. Sustain. Food Syst. 7:1254261.
doi: 10.3389/fsufs.2023.1254261

Agricultural literacy in artificial insemination and agribusiness management for social innovation in rural populations affected by armed conflict in Colombia

Yasser Y. Lenis[1], Amy Jo Montgomery[2], Diego F. Carrillo-González[1,3], Enoc Valentín González-Palacio[4], Dursun Barrios[5] and Mohammed A. Elmetwally[6,7]*

[1]Research Group OHVRI, School of Veterinary Medicine, Faculty of Agrarian Science, Universidad de Antioquia, Medellín, Colombia, [2]School of Medicine, St. George's University, West Indies, Grenada, [3]Faculty of Agricultural Sciences, Universidad de Sucre, Sincelejo, Colombia, [4]Universidad de Antioquia, Physical Education Institute, Medellín, Colombia, [5]Faculty of Agricultural Sciences, Universidad Nacional de Colombia, Bogotá, Colombia, [6]Department of Theriogenology, Faculty of Veterinary Medicine, Mansoura University, Mansoura, Egypt, [7]Center for Reproductive Biotechnology, Faculty of Veterinary Medicine, Mansoura University, Mansoura, Egypt

The achievement of education in rural populations was one of the Millennium Development Goals (MDGs), outlined by the United Nations. During the last World Summit on Sustainable Development (WSSD), it was concluded that the majority of the world's poor, illiterate and undernourished population lives in rural areas; therefore, access to education is considered one of the greatest challenges for governments in countries with developing economies. The purpose of this study was to determine how a theoretical-practical training program in rural management and leadership (D-ML), artificial insemination (D-AI), and bovine genetic improvement (D-GI) affected the perception and level of knowledge in a rural population affected by Colombia's armed conflict. Phase 1 included the theoretical and practical training of undergraduate animal sciences students in three dimensions (D-ML, D-AI, D-GI). After training, students were evaluated according to their level of theoretical-practical knowledge and their behavioral performance. There were 13 students selected to be a part of what we went on to call "the group of student leaders." Phase 2 included the socioeconomic characterization and training of rural residents by the group of student leaders and field experts in the same three dimensions (D-ML, D-AI, D-GI). We evaluated the perception and level of knowledge before and after training in 63 rural residents using an evaluative instrument. The perception of knowledge in rural residents was low for general knowledge (GTD) (2.48 ± 0.76, $p < 0.05$), D-ML (2.89 ± 1.18, $p < 0.05$) and D-AI/D-GI (2.17 ± 0.83, $p < 0.05$), in accordance with the 5-point Likert-type ordinal scale. When level of knowledge was measured before the theorical-practical training, the level of GTD was 45.9%, however, after the training it increased to 77.6% ($p < 0.01$), while the level of knowledge for D-AI increased from 38.5% pre-training to 80.6% ($p < 0.05$) post-training, and level of knowledge for D-GI pre-training was 50.8% and increased to 73.0% ($p < 0.01$) post-training. Finally, the level of knowledge for D-ML increased ($p < 0.01$) from 54.8% pre-training to 75% post-training. Altogether, rural extension programs contribute to closing knowledge gaps in

relation to the use of reproductive biotechnologies and bovine management in rural areas affected by armed conflict.

KEYWORDS

conflict areas, agricultural literacy, bovine reproduction, rural, artificial insemination

1 Introduction

Food security and food sovereignty both play pivotal roles in the development of a sustainable country that provides equality for its people (Ngongo et al., 2021). The current global population is 7.7 billion, with a projected increase to 11.2 billion by the end of the century (Joint FAO/WHO, 2004; Leridon, 2020). To achieve security and sovereignty for the growing world population, we must strengthen our agricultural skills and efficiency (FAO, 2012). According to the United Nations, Colombia has more than 78.9 thousand newly Internally Displaced Persons (IDPs) from January to June of 2022 (Council NR and De Balexert, 2010). However, the country's total IDP population represents 19% of the entire world's IDP population and it is estimated that 92% of the country's IDPs are located in rural areas (Council NR and De Balexert, 2010; Schultze-Kraft, 2019). In 2020, it was determined that 37.1% of the population in rural areas were impoverished, while in municipal capitals that number fell to 12.5%, showing that the poverty gaps are significantly increased in rural areas when compared to municipal capitals (Luna, 2021). One of the factors that influence this knowledge gap is the minor level of rural education and, in many cases, illiteracy in remote populations (Cruz Arcila, 2018). As the global population increases, the demand for cattle products created with sustainable and effective procedures rises (Ritchie and Roser, 2020; Ngongo et al., 2021).

Cattle production in Colombia has become an important economic resource, with the total population of cattle reaching 29 million. This field represents 3% of the total Gross domestic product (GDP), 26% of the agricultural GDP, and 60% of the livestock GDP (Arango et al., 2020). AI in cattle consists of depositing a small amount of semen from a genetically superior bull into a female that is close to ovulation, to seek a viable pregnancy (Lenis et al., 2021). However, to make AI a beneficial tool, there needs to be education and training available that outlines the benefits of this technique, when it is used correctly (Fekata et al., 2020). It is important to identify the appropriate and beneficial genotype to introduce into the livestock, based on the final product the producer is seeking, to optimize AI as a technique (Holden and Butler, 2018).

A solution for rural communities to improve education quality, opportunities, and family economics is through educators who share their knowledge in agribusiness, rural leadership, AI, and genetic improvement to these communities. In Colombia, the main challenges in bovine agribusiness are not only to increase inventory and productivity, but also to improve the application of science, technology, and innovation which promotes the optimization of production and the implementation of an eco-sustainable approach (FAO, 2019; Mullins et al., 2019; Silvi et al., 2021).

It's essential to recognize the untapped workforce that consists of rural leaders and undergraduate students. When attempting to improve the circumstances, possibilities, and standard of living for farmers in rural areas, our research has found this untapped potential to be a tremendous benefit for these communities. Rural leaders and undergraduate students are an important asset to achieve the Sustainable Development Goals (SDGs) set by the United Nations in 2020, in the areas of quality education, decent work and economic growth, reduced inequalities, sustainable cities and communities, responsible production, and partnerships for the goals (Estay, 2020). Our goal was to determine the effects of a theoretical-practical training program in D-ML, D-AI, and D-GI, on the perception and level of knowledge in a rural population affected by the Colombian armed conflict.

2 Methods

2.1 Selection of the sample and study area

Considering the social implications of this study, the selection of the beneficiaries included rural residents who met the following criteria: (1) lived in an area with an ongoing armed conflict; (2) lived outside of municipal capitals and major towns; (3) had a rural occupation producing cattle; and (4) lived in areas with little to no state presence in Colombia.

Following the selection criteria, the geographical areas selected to benefit were two municipalities located in the department of Nariño, which is in the south of Colombia. The first municipality selected was "*Los Andes Sotomayor*," which is 1,570 meters above sea level, with a population of 9,791 inhabitants, with 4,200 inhabitants located in the municipal capital and 5,591 inhabitants located in rural areas. The second municipality selected was "*La Llanada*," which is 2,300 meters above sea level, with a population of 5,321 inhabitants, with 2,822 inhabitants located in the municipal capital and 2,499 inhabitants located in rural areas. Both municipalities met the requirements of being in an ongoing armed conflict due to the presence of the illegal armed group identified as the "National Liberation Army" (ELN), suggesting little to no Colombian state presence. Additionally, both municipalities were located outside of municipal capitals and major towns and have a high livestock vocation oriented to the production of milk, beef, and dual purpose (milk and beef production).

2.2 Phase 1: socioeconomic characterization, training, and selection of the student population

A socio-economic characterization was performed in accordance with the guidelines from the National Statistical and Administration Department of Colombia (DANE) of Colombia, where individuals are ranked based on their monthly income as follows: Socioeconomic

status level 1: very low, level 2: low, level 3: middle low, level 4: middle, level 5: middle high, level 6: high.

The initial phase for selection included the theoretical and practical training of undergraduate animal science students and was performed during 6 theoretical conferences, which lasted for 45 min per session. The training was focused on leadership and rural communication, agribusiness, female reproductive anatomy, AI, and genetic improvement in bovines. These topics were offered by professors with doctoral degrees and expertise in their respective fields. Subsequently, 20 days after the theoretical training was completed, a 36-h practical session, which was split between 3 consecutive days, was held at a bovine production center that had a dual-purpose production system (milk and beef production). The students were broken up into groups of 9 to perform practical activities in each of the 6 learning stations. Each group of students rotated through stations 1 through 5 for 3 h each, and through station 6 for a total of 21 h.

> Station 1. Agribusiness and leadership: a collective discussion on the basic principles of rural management, agricultural extension methodologies, leadership, and social innovation.
>
> Station 2. Anatomy of the female bovine reproductive system: visualization of the anatomical landmarks of the reproductive system in the bovine female supported by real anatomical specimens and the book, *Reproduction of the cow: didactic manual on the reproduction, gestation, lactation, and well-being of the bovine female by* Lenis et al. (2014).
>
> Station 3. Blind identification: blind palpation of objects using various structures, consistencies, and sizes.
>
> Station 4. Insemination technique and catheter placement in anatomical pieces: assembly of the artificial insemination gun and blind access to the uterine body through the cervix of a real anatomical specimens.
>
> Station 5. Management of semen and liquid nitrogen tanks: basic concepts for the management, care, and maintenance of liquid nitrogen tanks and semen storage.
>
> Station 6. Rectal palpation of cows: the students performed rectal palpation in cows and identified the cervix as one of the initial steps for AI.

For the selection of the group of student leaders, at the end of the theoretical training sessions, a knowledge test on the three dimensions (D-ML, D-AI, and D-GI) consisting of 25 multiple-choice questions, with 4 choices for each question and a single correct answer was applied. During practical training sessions, each student took a practical test for each station which was consolidated and recorded as a numerical score to represent each student's practical knowledge. Furthermore, during practical training sessions a behavioral evaluation was recorded for each student by the professor in charge of each field, using an instrument designed by Lenis et al. (2023). The criteria for the selection of the students were: to obtain a minimum score of 90% on the two tests (theoretical and practical) and on the behavioral evaluation, as well as show an interest in participating in the next phase of the project. Once the theoretical and practical training sessions were completed, a consolidation of the applied tests and evaluation (theoretical knowledge, practical knowledge, and behavioral skills) was carried out and.

each student was given a numerical score. Finally, the top 13 students with the highest scores were selected to be a part of the group of student leaders.

2.3 Phase 2: socioeconomic characterization and training of rural residents

Before the beginning of training for participating rural residents, they were asked for information on their various socioeconomic realities. This included family composition, level of education completed, possession of land and animals, productive vocation, and economic standing. The training of the participating rural residents was carried out according to the same teaching protocol (by teaching stations) that was used for the training of the students. However, for the training of the rural residents the theorical and practical sessions were distributed in 3 days, training for 8 h per day.

2.4 Perception and level of knowledge for rural residents

To measure participants' perception of knowledge (subjective evaluation), the participating rural residents completed a unique knowledge perception survey prior to the start of the theoretical-practical training session. This survey included a 5-point Likert-type ordinal scale including the following: (1) Definitely not, (2) Probably not, (3) Undecided, (4) Probably yes, and (5) Definitely yes. The topics that were evaluated were grouped into three dimensions: D-ML, D-AI and D-GI.

For the objective evaluation of knowledge, the participating rural residents were evaluated individually with a test consisting of a total of 8 multiple-choice questions with a single answer, on the three dimensions (D-ML, D-AI and D-GI) and all three dimensions together were analyzed as general knowledge (GTD). The same test was applied before the start of the training (pre-test) and upon completion (post-test). The qualification was categorized in a nominal dichotomous way and recorded as successful (1) or not successful (0). This analysis was performed to evaluate the impact of theoretical and practical training on the appropriation of knowledge related to the three dimensions.

2.5 Statistical analysis

The normality of the variables was evaluated using the Shapiro–Wilk test ($p > 0.05$); the description of the variables was observed by using median (Me) and interquartile range (IR). The intra-subject

10.3389/fsufs.2023.1254261

comparisons used the Wilcoxon test, and for the correlation of variables the Spearman's rank test ($p < 0.05$) was used. The reliability or internal consistency of the instrument used to assess the perception of knowledge was confirmed by the Cronbach's Alpha model test ($\alpha \geq 0.7$), given the ordinal scale due to the nature of the data. The reliability or internal consistency of the instrument used to assess the levels of knowledge given the dichotomous nature of the data (1 = correct, 0 = not correct), was evaluated using Richarson's Kuder method (KR21) taking a reference value of $\alpha \geq 0.7$. The validation of the instruments applied to measure knowledge was determined by the group of experts who were involved in the study. Statistical analysis was performed using SAS® (version 9.2, SAS Institute).

3 Results

3.1 Socioeconomic characterization, training, and selection of the student population

Out of the 70 students trained theoretically, 66% identified as female and 34% as male, 34% of the participating students belong to a socioeconomic status level of 1, 46% to level 2, and 20% to level 3. Additionally, 62% of the students came from peri-urban or rural areas and 34% identify themselves as an afro-descendant, mulatto, or islander. Of the initial 70 student participants (Table 1) that received the theoretical training, only 52 students attended the practical session representing 74% of the initial student population.

Finally, 13 students were selected out of the 52, based on performance as described above in the theoretical and practical tests and behavioral evaluation, as well as expressed their interest in continuing the process of transferring technology to rural residents. These students formed what we call the "group of student leaders" who would later train rural residents.

3.2 Socioeconomic characterization and training of rural residents

The training included 63 rural participants, with an average age of 42 years, of which 71% declared to have been victims of the armed conflict. The participants were considered small producers, who had on average herds of 4 producing cows and 14 hectares of land (Barrios Hernández and Olivera Ángel, 2013). Regarding education level, 40% of the beneficiaries had completed primary education, 46% completed secondary education, 2% completed technical or technological studies, and only 12% had completed a university level education (see Table 2).

Households were mainly composed of a mother, father, and children (62%), 25% were single households, while 7 and 6% were fathers and mothers who were heads of households, respectively. Livestock farming represented the main source of income for 61% of the participants, followed by crop production (20%), mining (6%), and off-farm work activity (4%), while 9% recorded that they devoted themselves to other activities such as a student or a housewife.

3.3 Perception of knowledge for rural residents

Overall, the perception of general knowledge (GTD) by the participating was relatively low (2.48 ± 0.76) compared to the three dimensions when evaluated individually. The perception of knowledge in D-ML was higher, without being good (2.89 ± 1.18), meanwhile, the perception for D-AI / D-GI was lower compared to the previous one (2.17 ± 0.83). The instrument used for the measurement presented reliability in Cronbach's alpha model of 0.78, which represents good reliability of the questions used in this tool. The consistency or degree of confidence of the knowledge evaluation through the written test was validated by applying the Richarson's Kuder method (KR21), which obtained a value of 0.83, indicating that this evaluative instrument is likely to be applied in future projects that seek to diagnose the state of knowledge in the three dimensions evaluated in a rural population. Initially, an intra-subject comparison was performed between the results of the pre-test and the post-test after the intervention, for which the normality criteria were initially determined from the Shapiro–Wilk test of the dimensions evaluated (D-ML, D-AI and D-GI) and GTD, finding that all presented a non-normal distribution ($p<0.05$).

3.4 Leve of knowledge for rural residents

Subsequently, compliance with the study hypotheses (H0:MeO1 = MeO2; H1:MeO1 ≠ MeO2) was determined using a non-parametric test (Wilcoxon test, $\alpha < 0.05$) derived from the analysis of the distribution of the variables to be contrasted. It was established that the training of the participating rural residents had positive and statistically significant effects ($p < 0.01$; Table 3) on GTD. The median value in the pre-test went from 4.0 (IR = 3.0) to 6.0 (IR = 2.0). The level of knowledge in each test was measured by the number of correct answers by each participant and later this number was expressed as a percentage (%). The level of GTD evaluated before starting the training was 45.9%. However, once the training was completed, this value increased to 77.6%, showing a net increase of 31.7% ($p < 0.01$).

TABLE 1 Socioeconomic characterization of the initial student population.

	Gender		Average age (years)	Socioeconomic status level (1 to 6)			Geographic region origin			Ethnic Group*	
	Women	Men	(min–max)	1	2	3	Rural	Peri-urban	Urban	Belong	Not belong
Percentage (%)	66	34	23 (19–32)	34	46	20	24	38	38	34	66

*Afro-descendant, mulatto, or islander.

TABLE 2 Origin, education level and victim identity of rural residents.

Identifies as a victim of the armed conflict	Municipality origin		Educational level			
71%	Los Andes sotomayor	La llanada	Primary Education	Secondary education	Technical school	University
	40%	60%	40%	46%	2%	12%

TABLE 3 Pre-test and post-test Wilcoxon results.

Variable	Me	RI	p	d	1-β
Pre-test GTD	4,00	3,00	0,000	1,26	1,00
Post-test GTD	6,00	2,00			
Pre-test D-ML	1,00	1,00	0,001	0,45	0,80
Post-test D-ML	2,00	1,00			
Pre-test D-AI	2,00	1,00	0,000	1,48	1,00
Post-test D-AI	3,00	1,00			
Pre-test D-GI	1,00	2,00	0,000	0,50	0,89
Post-test D-GI	2,00	1,00			
$n=63$, $\alpha=0{,}01$					

Synthesis of results derived from the comparison between the pre-test and the post-test (Wilcoxon) after the intervention plan in knowledge regarding rural management and leadership (D-ML), artificial insemination (D-AI), and bovine genetic improvement (D-GI), (Me = median and RI = Interquartile range).

On the other hand, it was possible to determine that the size of the effect of the intervention was large ($d>0.80$) and its statistical power ($1\text{-}\beta=1.0$) very high, indicating an improvement in knowledge in all the subjects who did part of the training (Figure 1).

In the analysis by dimensions, the one referring to D-AI (Table 3), also presented statistically significant changes ($p<0.01$), and high effect size and statistical power ($d>0.80$; $1\text{-}\beta=1.0$; Figure 2). The level of knowledge related to the D-AI was 38.5% before the start of the training and increased to 80.6% at the end of the training ($p<0.01$). These results showed an increase of 42.1% after the intervention.

The level of knowledge in D-GI went from 50.8 to 73.0% before and after the training, generating a change of 22.2% ($p<0.01$) attributable to the training days. This dimension presented a medium effect size ($d=0.50$) and a high statistical power ($1\text{-}\beta=0.89$; Figure 3).

Finally, the level of knowledge related to D-ML was 54.8% before the start of the training sessions and 75% at the end; an improvement of 20.6% with a significant difference ($p<0.01$) before and after training (Table 3). The effect size ($d=0.45$) was in a small assessment and its statistical power was high ($1\text{-}\beta=0.80$; Figure 4).

On the other hand, a low but statistically significant positive correlation was found ($r_s=0.306$; $p<0.05$; $R^2=0.094$; $w=0{,}30$; $1\text{-}\beta=0.68$) between the subjective perception of knowledge versus objective knowledge in each rural population evaluated before the intervention, with a medium effect size ($w=0.3$) and a barely acceptable statistical power ($1\text{-}\beta=0.68$).

4 Discussion

For more than 60 years, Colombia has faced an intense and violent armed conflict between the State and illegal groups, many of them labeled as revolutionary guerrilla groups (Franco et al., 2006). As a result of the armed conflict and exacerbated by the policies of a centralized government with a low presence in some rural geographic areas of the country, it is estimated that more than 90% of the total displaced population in Colombia is of rural or semi-rural origin. This affects Colombia's agricultural productive capacity, hinders access to education and disintegrates the family nucleus of rural residents (Murad, 2003; Carrasco et al., 2009; Ibanez, 2009). Interestingly, more than 70% of the rural participants in the survey recognized themselves as victims of the armed conflict in Colombia and had a low level of schooling, with only 12% having completed a university level of education.

A strategy to strengthen agricultural literacy is through the involvement of undergraduate students who have a high degree of commitment, sensitivity, and leadership in extension projects, considering this initiative as part of social innovation (Oganisjana et al., 2017; Krstikj, 2021). Social innovation assists in problem solving in a society to enable the residents to improve their living conditions by generating projects and initiatives that include social or human potential (Osburg and Schmidpeter, 2013). Therefore, universities play unique and important roles, becoming key instruments for social transformation, through the implementation of outreach activities that promote and enhance relationships between teachers and students so that the students can become transforming agents of education in a society (Arocena and Sutz, 2021). The unique qualities and abilities of each student should be identified and encouraged, to subsequently be used as strategies as part of a solution to social issues in vulnerable communities (Gugerty and Teeven, 2015).

According to the analysis performed by dimensions, it is possible to infer that the training had a positive effect on the rural residents, making it an important tool to strengthen human capital and improve productive skills and the ability to process information of the rural population (Anderson and Feder, 2003). In the case of D-AI, statistically significant changes, high effect size and statistical power were obtained, indicating that in this component it is possible to infer a positive effect in the investigated subjects. In the D-GI, although the effect size was medium, there was a statistically significant difference between the pre-test and the post-test after the intervention and a very good statistical power, which indicates that it is unlikely (11%) to commit a type 2 error if the null hypothesis is rejected. Therefore, it can be inferred that the intervention process was successful in terms of the acquisition of knowledge related to D-GI in the intervened group. Finally, the level of knowledge related to the D-ML suggests an improvement with a significant difference between the pre-test and post-test, and a small effect size with a high statistical power; which implies that the knowledge related to D-ML were successful, although the probability of being wrong when rejecting the null hypothesis is at the limit of what is allowed (20%), so for future interventions, it is suggested to implement strategies of

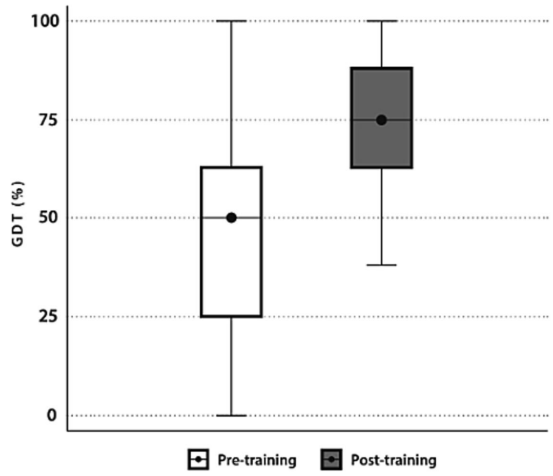

FIGURE 1
Rural residents' level of general knowledge (GTD), including rural management and leadership (D-ML), artificial insemination (D-AI), and bovine genetic improvement (D-GI) before and after the training sessions. Level of knowledge was expressed in percentage, circles represent the medians of the samples, and boxes show 25th and 75th percentiles.

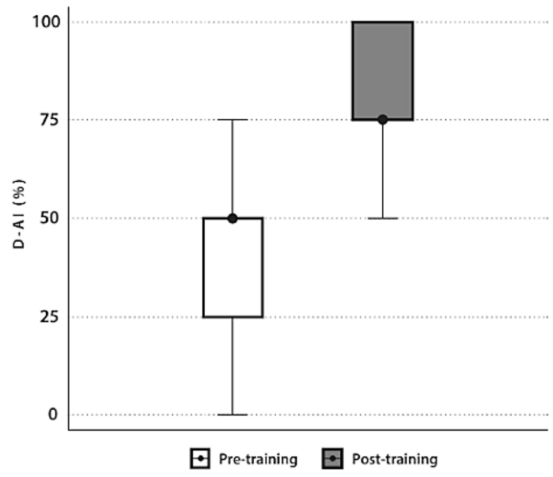

FIGURE 2
Level of knowledge in artificial insemination (D-AI) in rural residents before and after the training sessions. Level of knowledge was expressed in percentage, circles represent the medians of the sample, and boxes show 25th and 75th percentiles.

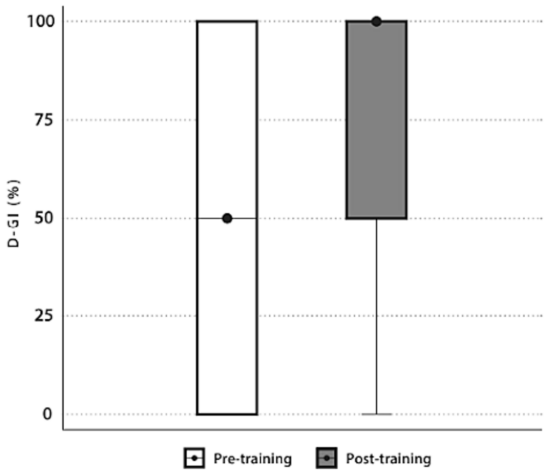

FIGURE 3
Level of knowledge in bovine genetic improvement of rural residents (D-GI) before and after the training sessions. Level of knowledge was expressed in percentage, circles represent the medians of the sample, and boxes show 25th and 75th percentiles.

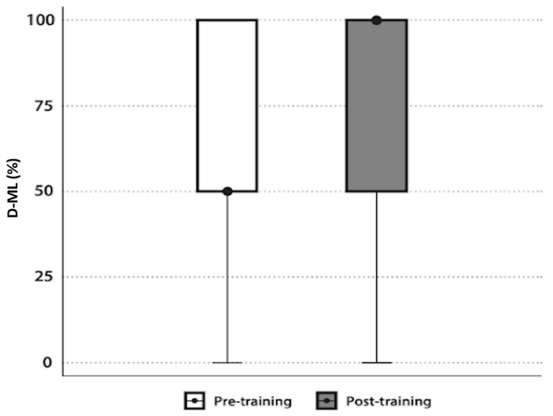

FIGURE 4
Level of knowledge of rural residents in rural management and leadership (D-ML) before and after the training sessions. Level of knowledge was expressed in percentage, circles represent the medians of the sample, and boxes show 25th and 75th percentiles.

didactic order that allow a greater appropriation of this theme in subjects with similar characteristics.

The correlation analysis of the values obtained in the perception of knowledge (subjective) compared to the level of knowledge (objective) of each evaluated rural population; indicates that those who have a low perception of knowledge show an equally low score in the objective test of knowledge. However, the statistical findings show that although the perception of the study participants tends to be closer to their levels of knowledge, this is not the same across the group, so using the instrument on the objective knowledge that was used to evaluate the three dimensions becomes more appropriate to effectively determine their knowledge and level of appropriation in the intervention topics.

Up to the date of writing this work, this is the first report of an evaluation of knowledge before and after 3 days of theoretical-practical training led by undergraduate students to rural residents affected by an armed conflict. However, Fekata and colleagues in 2020 evaluated the perception of estrous synchronization and AI in cows in 122 rural residents, who showed low credibility and perception in relation to these two techniques. Interestingly, the authors propose to evaluate for future studies the knowledge of producers in estrous synchronization and insemination and conclude that increasing the degree of knowledge and training of the participants would favor technological adoption and positive perception toward these two techniques.

We discovered that the rural participants in this study believed their knowledge in these areas to be limited when assessing their sense of expertise in the topics reviewed before the training. This result was obtained after a previous statistical validation of the reliability of the instrument used to measure the perception of knowledge and coincides with some of the findings described by Frick et al. (1995) in where the level of education of the participants influenced the number of correct answers obtained. The primary goal of rural extension is to enable extension agents to effectively impart information to rural producers, enabling them to make better decisions and adopt productive practices that enhance their living situations (Koch and Hayward, 1990; Anderson and Feder, 2003).

Although the effect of teaching and learning on AI in cattle had not been evaluated in rural populations affected by the armed conflict, Dalton and colleagues in 2021 designed an extension program to facilitate the appropriation of knowledge and practical skills related to AI in students in veterinary medicine (Dalton et al., 2021). This study allows us to conclude that after the training program, the students developed effective skills that allowed them to pass the knowledge tests applied. Therefore, it is important to implement new didactic strategies for teaching programs that improve the quality of life for students and rural residents (Lenis et al., 2013; Landini and Brites, 2018). Given that the intention of the present study was to evaluate the effect of theoretical-practical training on knowledge in the three dimensions in rural residents who are victims of the Colombian armed conflict, an instrument was designed that would allow for assessment of the essential elements learned by the participants during the training days. Interestingly, the level of general knowledge in the participants, which included theoretical elements of each of the topics offered, increased with a high degree of effect size after the completion of the three training days.

5 Conclusion

In conclusion, the theoretical and practical training process showed a positive impact in the acquisition of useful and novel knowledge based on D-ML, D-AI, and D-GI in a group of rural residents from the Department of Nariño in Colombia, South America. These kinds of studies can enhance the production conditions in the rural sector and in populations affected by armed conflict.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by National University of Colombia Sede Palmira. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YL: Conceptualization, Data curation, Investigation, Supervision, Writing – original draft, Writing – review & editing, Funding acquisition, Methodology, Project administration, Resources. AM: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing, Formal analysis, Software. DC-G: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. EG-P: Conceptualization, Formal analysis, Methodology, Writing – original draft, Data curation, Investigation. DB: Data curation, Formal analysis, Methodology, Writing – original draft, Software, Writing – review & editing. ME: Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Conceptualization, Investigation, Supervision.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was supported by St. George's University, West Indies, Grenada and National University of Colombia, Palmira. Grant number/QUIPU # 317010032741 from Solidarity Extension Grants, 2021.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Anderson, J. R., and Feder, G. (2003). *Rural extension services, policy research working papers*. Washington, DC: The World Bank.

Arango, J., Ruden, A., Martinez-Baron, D., Loboguerrero, A. M., Berndt, A., Chacón, M., et al. (2020). Ambition meets reality: achieving GHG emission reduction targets in the livestock sector of Latin America. *Front. Sustain. Food Syst.* 4:65. doi: 10.3389/fsufs.2020.00065

Arocena, R., and Sutz, J. (2021). Universities and social innovation for global sustainable development as seen from the south. *Technol. Forecast. Soc. Change* 162:120399. doi: 10.1016/j.techfore.2020.120399

Barrios Hernández, D., and Olivera Ángel, M. (2013). *Análisis de la competitividad del sector lechero: caso aplicado al norte de Antioquia*, Colombia. Innovar, p. 23.

Carrasco, T., Tomaso, R. D., and Valenzuela, M. D. (2009). *Retos para la integración social de los pobres en América Latina*. Buenos Aires: CLASCO.

Council NRDe Balexert, C. (2010). *Internal displacement monitoring Centre. Project: Profile of the internal displacement*. Geneva: Switzerland: Norwegian refugee council Chemin de Balexert 7–9 1219 Châtelaine. https://www.internal-displacement.org.

Cruz Arcila, F. (2018). The wisdom of teachers' personal theories: creative ELT practices from colombian rural schools. Profile: issues teach. *Prof. Dev.* 20, 65–78. doi: 10.15446/profile.v20n2.67142

Dalton, J. C., Robinson, J. Q., Price, W. J., DeJarnette, J. M., and Chapwanya, A. (2021). Artificial insemination of cattle: description and assessment of a training program for veterinary students. *J. Dairy Sci.* 104, 6295–6303. doi: 10.3168/jds.2020-19655

Estay, P. M. (2020). *Resumen Informe de los Objetivos de Desarrollo Sostenible 2020: los efectos del COVID-19 en el cumplimiento de los ODS*. Asesorías Parlamentarias Programa Asia Pacífico–Departamento de Estudios, Extensión y Publicaciones Biblioteca del Congreso Nacional.

FAO. (2012). *Escala Latinoamericana y Caribeña de Seguridad Alimentaria (ELCSA)–Manual de uso y aplicación*.

FAO. (2019). *El Estado Mundial de la Agricultura y la Alimentación. Progresos en la Lucha Contra la Pérdida y el Desperdicio de Alimentos*. Rome, Italy: FAO

Fekata, A., Galmessa, U., Fita, L., Merera, C., and Bekuma, A. (2020). Dairy cattle producers' perception on Oestrus synchronization and mass artificial insemination services in Waliso and Ilu districts of south west Shoa zone of Oromia. *Ethiopia. Insights Vet Sci.* 4, 010–013. doi: 10.29328/journal.ivs.1001020

Franco, S., Suarez, C. M., Naranjo, C. B., Báez, L. C., and Rozo, P. (2006). The effects of the armed conflict on the life and health in Colombia. *Cien. Saude Colet.* 11, 349–361. doi: 10.1590/S1413-81232006000200013

Frick, M. J., Birkenholz, R. J., and Machtmes, K. (1995). Rural and adult knowledge and perceptions of agriculture. *JAE* 36, 44–53. doi: 10.5032/jae.1995.02044

Gugerty, P., and Teeven, B. (2015). Leadership and creativity are important for undergraduate students: our journey. *J. Ldrsh. Stud.* 9, 90–91. doi: 10.1002/jls.21419

Holden, S. A., and Butler, S. T. (2018). Review: applications and benefits of sexed semen in dairy and beef herds. *Animal* 12, s97–s103. doi: 10.1017/S1751731118000721

Ibanez, A. M. (2009). Forced displacement in Colombia: magnitude and causes. *EPSJ* 4:48. doi: 10.15355/epsj.4.1.48

Joint FAO/WHO. (2004). *Evaluation of certain food additives and contaminants: sixty-first report of the joint FAO/WHO expert committee on food additives*. Geneva: World Health Organization.

Koch, B. H., and Hayward, J. W. (1990). Effective extension for increased productivity and a better quality of life. *Dev. South. Afr.* 7, 389–400. doi: 10.1080/03768359008439533

Krstikj, A. (2021). Social innovation in the undergraduate architecture studio. *Societies* 11:26. doi: 10.3390/soc11010026

Landini, F., and Brites, W. (2018). Evaluation and impact of a reflective training process for rural extension agents. *J. Agric. Educ. Ext.* 24, 457–472. doi: 10.1080/1389224X.2018.1500922

Lenis, Y. Y., Carrillo, D., and Arango, L. T. (2013). *Modelos didácticos como estrategia para la enseñanza y el aprendizaje de los Sistemas Orgánicos Animales en la Facultad de Ciencias Agrarias de la Universidad de Antioquia Uni-pluriversidad*. Uni-pluriversidad.

Lenis, Y. Y., González, D. C., and Barrios, D. (2021). *Inseminación artificial y liderazgo rural en el agronegocio bovino*. Colombia: Universidad Nacional de Colombia, 2021 Edition.

Lenis, Y. Y., Montgomery, A., Carrillo-Gonzalez, D. F., González Palacio, E., Barrios, D., and Duque, N. (2023). *Education as social innovation in rural populations affected by armed conflict (67870). The Asian conference on Education & International Development (ACEID)*. Available at: https://aceid.iafor.org/presentation/submission67870/.

Lenis, Y. Y., Tamaño, A. L., Rodríguez, O. N., Duque, M. L., Naranjo, N. J., Carillo, G. D., et al. (2014). *Reproducción de la vaca: manual didáctico sobre la reproducción, la gestación, la lactancia y el bienestar de la hembra bovina*. 1a edición.

Leridon, H. (2020). Population mondiale:vers une explosion ou une implosion? *Popul. Soc.* 573, 1–4. doi: 10.3917/popsoc.573.0001

Luna, S. R. (2021). *El Acuerdo de Paz entre las FARC y el Estado colombiano: Construyendo paz para construir Estado*. Papel Político.

Mullins, I. L., Truman, C. M., Campler, M. R., Bewley, J. M., and Costa, J. H. C. (2019). Validation of a commercial automated body condition scoring system on a commercial dairy farm. *Animals (Basel)* 9:287. doi: 10.3390/ani9060287

Murad, R. (2003). *Estudio sobre la distribución espacial de la población en Colombia. Proyecto regional de población Centro Latinoamericano y Caribeño de Demografía (CELADE), División de Población de la CEPAL/Fondo de Población de las Naciones Unidas (UNFPA) Población y desarrollo*. Santiago de Chile, noviembre de 2003. Available at: https://repositorio.cepal.org/server/api/core/bitstreams/a0c3181a-2847-4c1e-9e3a-6c18066f4db6/content.

Ngongo, Y., Kotta, N., and Matitaputty, P. R. (2021). Strengthening archipelago food security and food sovereignty in ENT–Indonesia. *IOP Conf. Earth Environ. Sci.* 803:012032. doi: 10.1088/1755-1315/803/1/012032

Oganisjana, K., Svirina, A., Surikova, S., Grīnberga-Zālīte, G., and Kozlovskis, K. (2017). Engaging universities in social innovation research for understanding sustainability issues. *Entrep. Sustain. Issues* 5, 9–22. doi: 10.9770/jesi.2017.5.1(1)

Osburg, T., and Schmidpeter, R. (2013). *Social innovation*. Berlin, Heidelberg: Springer.

Ritchie, H., and Roser, M. (2020). *Environmental impacts of food production. Our world in data*. Available at: https://ourworldindata.org/environmental-impacts-of-food.

Schultze-Kraft, M. (2019). *Crimilegal orders, governance and armed conflict*. Cham: Springer International Publishing.

Silvi, R., Pereira, L. G. R., Paiva, C. A. V., Tomich, T. R., Teixeira, V. A., Sacramento, J. P., et al. (2021). Adoption of precision technologies by brazilian dairy farms: the farmer's perception. *Animals (Basel)* 11:488. doi: 10.3390/ani11123488