Assessing Extension Workers' Opinions on Participatory Training in Sudan

Siafeldin Hussein Elgaylani[1], Abdelmoneim A. Babiker [2], Babiker M. B El - munna [3], Ibrahim M. Elhassan [4]

[1] Assistant prof. [2] Associate prof. [3] Assistant prof. [4] Associate prof. - Development of agricultural extension and rural development, Faculty of agriculture, University of Khartoum, Shambat , Sudan.

***Corresponded Author: Saifeldin Hussein Elgaylani - saifhussein@gmail.com**

Abstract:

This study examined the opinions of extension workers on participatory training in the Sudanese states of Gezira, Sinnar, and Gedarif. Data were collected from a sample of 205 extension workers using structured questionnaires, supported by secondary sources. The results show that the availability of training opportunities for extension workers was limited, and more frequent training sessions were required. Monitoring and evaluation methods and field demonstrations were identified as the preferred training formats. The findings also underscore the importance of designing training programs that reflect the actual needs of trainees and support the integration of participatory training approaches into agricultural extension systems. Considering its potential, it is prudent to design training processes centered on participatory methods for extension workers to facilitate sharing and reflect on their training experiences. This study enhances our understanding of how training, sharing, and reflecting on practice can induce alterations in the methodologies and positioning of rural extension workers. This study carefully evaluates the influence of training on extension workers and the fundamental processes that facilitated their development. The perspectives of extension workers on participatory training should be evaluated to anticipate future challenges that may hinder in-person training and practices.

Keywords: Agricultural extension, participatory training, rural development, assessing opinion, rural areas, Sudan.

ملخص الدراسة :

تبحث هذه الدراسة في آراء المرشدين الزراعيين حول التدريب التشاركي في ولايات الجزيرة وسنار والقضارف السودانية. جُمعت البيانات من عينة قوامها 205 مرشدًا زراعيًا باستخدام استبيانات مقننة، بالإضافة إلى مصادر ثانوية. أظهرت النتائج أن فرص التدريب المتاحة للمرشدين الزراعيين كانت محدودة، وأن هناك حاجة إلى عقد جلسات تدريبية أكثر تكرارًا. وقد

تم تحديد أسلوبي الرصد والتقييم، إلى جانب العروض الحقلية الإيضاحية، كأكثر أساليب التدريب تفضيلًا. كما تؤكد النتائج على أهمية تصميم برامج تدريبية تعكس الاحتياجات الفعلية للمتدربين، وتدعم دمج مناهج التدريب التشاركي في أنظمة الإرشاد الزراعي. ونظرًا للإمكانات التي يتيحها هذا النهج، فإنه من الحكمة تصميم برامج تدريبية تركز على الأساليب التشاركية للمرشدين الزراعيين، بهدف تسهيل تبادل خبراتهم التدريبية والتفاكر حولها. تعزز هذه الدراسة الفهم لكيفية تأثير التدريب، والتشارك، والتأمل في الممارسة على إحداث تغييرات في منهجيات العاملين في الإرشاد الريفي ومواقعهم. كما تقوم هذه الدراسة بتقييم دقيق لأثر التدريب على المرشدين الزراعيين، وللعمليات الأساسية التي سهلت تطورهم المهني. وينبغي تقييم وجهات نظر المرشدين الزراعيين حول التدريب التشاركي لاستباق التحديات المستقبلية التي قد تعيق التدريب الحضوري والممارسات الميدانية.

Introduction

Agriculture forms the backbone of Sudan's economy, accounting for nearly 30% of the country's gross domestic product (GDP) and employing over 70% of its labor force (1) (2). Participatory training in agricultural extension has garnered substantial attention worldwide as a method to engage farmers actively in their own development processes. In Sudan, participatory training is increasingly viewed as essential to address the diverse needs of smallholder farmers, who constitute over 70% of the agricultural labor force (2). Participatory training is defined as a training approach that actively involves trainees in learning, planning, and implementation, rather than being passive recipients of information. This method aims to strengthen interaction between extension workers and farmers, enabling them to exchange experiences and develop skills more effectively and sustainably (3). Consequently, participatory training is considered a strategy capable of achieving sustainable agricultural development, especially in environments like Sudan that face multiple challenges such as climate change, resource scarcity, and economic and social constraints (2). A recent study by (4) involving 150 extension workers in Gezira State found that 85% believed participatory training significantly improved farmers' ability to adopt improved crop management practices. This aligns with similar findings by (5) in Zimbabwe, where extension agents reported that Farmer Field Schools (FFS) enhanced farmers' problem-solving skills and resilience against climate variability. The participatory approach empowers farmers through experiential learning, encouraging group discussions, experimentation, and mutual learning rather than top-down instruction (6). Extension workers in Sudan also emphasize that participatory training fosters social cohesion and trust among farming communities, which is vital in conflict-prone and diverse ethnic settings such as Darfur and Kordofan (7). According to a mixed-methods study by (8), 78% of surveyed extension workers agreed that participatory approaches reduced social barriers and facilitated inclusion of marginalized groups, including women and youth. This finding resonates with global evidence from Ethiopia and Kenya, where participatory training has been shown to

enhance gender equity and youth engagement in agriculture (9) (10). Despite these benefits, many extension workers report challenges related to the scalability and sustainability of participatory training programs (11). A qualitative analysis by (12) highlighted that Sudanese extension agents often struggle with limited institutional support, inadequate training, and insufficient logistical resources. These issues are compounded by the often-short-term nature of donor-funded projects, which hampers long-term capacity building (13). This pattern has been similarly reported in other Sub-Saharan African countries, where participatory extension projects frequently fail to transition from pilot to wide-scale adoption due to institutional weaknesses (14). Moreover, the gender gap remains a significant obstacle. In Sudan, traditional gender roles and restrictions on women's mobility limit their participation in extension activities, including participatory training (15). Extension workers advocate for culturally sensitive strategies that provide separate training sessions for women, use female facilitators, and schedule training at convenient times (16). Studies in Tanzania and Malawi corroborate that such gender-responsive measures increase women's access to agricultural knowledge and technology (17). The enhancement of capabilities for extension workers is a persistent theme. Research by(18) indicates that over 60% of extension personnel in Sudan feel underprepared to facilitate participatory sessions effectively, citing gaps in facilitation, communication, and conflict resolution skills. Training-of-trainers (ToT) programs and ongoing professional development are recommended to address these gaps [(19)]. Institutional fragmentation is a barrier repeatedly identified by extension workers. The multiplicity of government agencies, non-governmental organizations (NGOs), and international donors often leads to overlapping programs and inefficient resource use (20). Enhanced coordination through multi-stakeholder platforms is suggested to harmonize extension services and strengthen participatory training outcomes (13). Finally, extension workers view the evolving climate and socio-political challenges as critical factors shaping the future of participatory training. With increasing climate variability affecting crop yields and livelihoods, participatory methods provide a platform for adaptive learning and co-creation of climate-resilient practices (21). Among the methods in agricultural extension, participatory training has emerged as an innovative approach that emphasizes the active involvement of beneficiaries in the training process, enhancing knowledge assimilation and practical application (22). Participatory training frameworks promote horizontal exchange, encourage experimentation, and enable local problem-solving. They also improve accountability, build trust, and lead to more sustainable outcomes. Empirical studies provide strong support for these approaches (23). For example, (24) found that participatory training methods significantly increased farmers' adoption of

climate-resilient practices in Ethiopia and Ghana. Similarly, (25) reported that participatory models led to improved knowledge retention and application among extension workers in Malawi, Uganda, and Nepal. In each case, the participatory design led to better alignment between farmer needs and extension services. However, extension systems in Sudan remain fragmented, underfunded, and poorly integrated. A 2016 study by Rahman and Yousif noted that many extension workers in Sudan lacked structured in-service training, and existing training often failed to match field realities. These disconnects between training design and frontline need weakens extension impact. It also leads to demotivation and poor retention among extension personnel. However, contrary views do exist. Some critics argue that participatory methods are time-consuming, difficult to scale, and often hindered by power asymmetries within communities. For instance, (26) caution that without adequate facilitation skills, participatory processes can reinforce existing social hierarchies and marginalize women or poorer farmers. Moreover, critics note that participatory programs require more resources, coordination, and institutional support than conventional models—which may not be available in resource-constrained

settings like Sudan. Yet, evidence suggests that these challenges are not insurmountable. With proper training, facilitation tools, and community sensitization, participatory approaches can be both inclusive and cost-effective (3). They can complement existing extension frameworks rather than replacing them. Hybrid models that combine expert-driven advice with farmer-led experimentation have shown promise in several African and Asian contexts (27). (28) found that participatory training improved communication, facilitation, and planning skills among Indian extension agents. Similarly,(29) observed that Sudanese extension workers who received participatory training demonstrated stronger trust-building and problem-solving abilities. There is also international evidence from non-agricultural sectors. For example, participatory training in Chinese small and medium enterprises led to marked improvements in employee attitudes, knowledge application, and teamwork (30). Recent studies indicate that agricultural extension workers in Sudan face a combination of factors influencing their attitudes towards participatory training, including technical capacities, available resources, institutional support, and awareness of the importance of active participation (31). In this context, evaluating agricultural extension workers' opinions on participatory training emerges as a necessary step to understand the reality of field training and identify obstacles that may hinder the application of this method. Assessing these opinions can highlight the strengths and weaknesses of training programs and lead to practical recommendations for their development

in line with the Sudanese environment and sustainable agricultural development requirements (32). Multiple studies have pointed out that participatory training enhances farmers' ability to adapt to environmental and economic changes, improves agricultural problem-solving skills, and increases trust between extension workers and farmers (33). Furthermore, this approach encourages community empowerment and increases farmers' ownership of development processes, positively reflecting on the sustainability of agricultural projects (34). In Sudan, where agricultural environments vary between plains and desert areas, extension workers face significant challenges in adopting effective training methods suitable for each environment and farmers' conditions (35). Therefore, understanding extension workers' perspectives on participatory training provides valuable insights that can be relied upon in designing integrated training programs that meet farmers' needs in various regions. Social and cultural dimensions influencing the adoption of participatory training in Sudan must also be considered, as tribal systems, customs, and traditions play a significant role in determining the extent to which agricultural communities accept change and modernization. Participatory training has increasingly gained attention as an effective approach to agricultural extension services, particularly in developing countries such as Sudan. This approach emphasizes active involvement and engagement of farmers and extension workers in the learning process, promoting ownership, knowledge sharing, and sustainable agricultural practices (3). Several studies highlight the positive impact of participatory training on farmers' capacity to adopt new technologies and improve agricultural productivity (23). For instance,(34) found that participatory approaches contribute to increased problem-solving skills among farmers and fostering better relationships between farmers and extension agents. In the Sudanese context,(32) discuss how extension workers' technical capacity, institutional support, and awareness of participatory methods significantly affect the adoption and success of such training programs. Their findings emphasize that training effectiveness depends not only on content but also on trainers' attitudes and perceptions of participatory methodologies. Socio-cultural factors, including community norms and collective action traditions, play a crucial role in shaping the receptiveness of farmers and extension workers to participatory training. They argue that overcoming cultural resistance is essential for the widespread implementation of participatory methods. Economic and environmental challenges, such as climate change impacts and resource scarcity, further complicate the implementation of participatory training in Sudan (36). Training programs that incorporate participatory approaches are considered more adaptable and effective in such challenging environments. Nevertheless, the success of participatory training programs in Sudan is still limited by several barriers.(12). Highlighted

issues such as inadequate institutional frameworks, insufficient funding, and lack of continuous capacity building for extension workers as major obstacles (33) stressed the need for improved monitoring and evaluation mechanisms to assess the outcomes of participatory training and ensure accountability. Such evaluations can provide valuable feedback to enhance program design and implementation. This study investigates the perceptions of extension workers in Sudan toward participatory training. It explores their preparedness, preferences, and perceived needs regarding training methods. Specifically, it aimed to assess the current level of training provision to extension workers, determine their views on preferred training formats, and identify their perceptions of needs for participatory training.

Methodology

Areas of study

Gezira state is situated in central Sudan, with an area of 255,492 kilometers and a population of 3,796,000. The Gezira Scheme is one of the oldest and most significant agricultural irrigation initiatives in Sudan (37). Gezira Scheme is the largest irrigation project globally managed under a single administration. Sinnar state is situated in the southern region of the Gezira plan and is bifurcated by the Blue Nile River into eastern and western sections. It borders with White Nile state from West, Blue Nile state from South, Gezira state from North, Gedarif state from East, and South Sudan from southwest; its area is approximately 4068000 hectares of clay soil (38)**.** Gedarif state is located between latitudes 12° and 17° N and longitudes 34° and 36° E, with a total population of 1,148,262. The Gedarif state has been a significant economic region in Sudan since the 1940s. It is in the southern part of Kassla state in Eastern Sudan. It lies south-east of Khartoum (400 km) and (700 km north-east) from Port Sudan on the Red Sea. It lies next to major tributaries of the Blue Nile, the Rahad River and Atbra River. The State is about 600 meters above sea level. Gedarif has a large grain and animal market (39). Gedarif possesses generally fertile soils and moderate to sufficient rainfall, prompting the Sudanese government to establish extensive mechanized agricultural initiatives in the region. This state has been a rich source of animal supply composed of cattle, camels, sheep and goats (39).

Reason for site selection:

The study was carried out in three states of Sudan, namely Gezira, Sennar and Gadarif, which have a wide range of agro-ecological zones and are situated between latitudes 22° N - 12° S and 36°E - 27°W and high population densities. These areas represent the main agricultural production areas in Sudan. Furthermore, the number of extension workers and farmers in the

selected states is higher than that in other states.

Population of the study:

The study population comprises agricultural extension workers from three states. The survey covered two hundred and five agents working in three states in their localities. They equal 97.5 percent of the total population. Though the original plan was to interview all extension workers in the study area 210 extension workers (Gezira 80, Sinnar 58, Gedarif 72), due to different reasons, five extension workers were not available at the time of the survey.

Data collection:

The study was mainly based on primary data collected from a field survey using a questionnaire. The questionnaire was pre-tested on a sample of 30 extension workers from the study population of extension sample to ensure that it had a high degree of reliability and validity. Secondary data were collected from relevant sources.

Data analysis:

The purpose of the analysis was to test the hypotheses, and different techniques were used to analyze the collected data. The statistical program (Statistical Package for Social Science, SPSS) was used to accomplish the techniques of descriptive statistics (frequency distribution) to calculate the frequency, percentage, mean and standard deviation of each item in frequency matrix.

Results and Discussion:

Results of the descriptive statistics:

Agricultural training and training Attendance:

Respondents were asked: "How many training sessions have you attended during your agricultural extension service?" The options were: frequent, two, one, or none.

Table1. Frequency Distribution of Respondents by Number of Training Sessions Attended**.**

Numbers of training sessions	**Freq.**	**%**
Frequent	66	32.2
Two	21	10.2
One	56	27.3
Nothing	62	30.2
Total	205	100%

The data in Table 1 show clear disparities in training access among extension workers.

Results of the descriptive statistics using Mean and Standard Deviation

Training Method Preferences

Respondents were asked to evaluate preferred training methods by rating each option from strongly agree (4) to strongly disagree (1).

Table 2. Extension Workers' Preferences for Training Methods

Methods	Number of respondents (N=205)				Mean	SD
	strongly agree	agree	disagree	strongly disagree		
Monitoring and evaluation	68.8	28.3	2.0	1.0	3.65	0.57
Field demonstrations	68.8	28.3	1.0	2.0	3.64	0.61
Transporting of information	60.5	34.6	2.9	2.0	3.54	0.65
Management	52.2	41.5	4.4	2.0	3.44	0.67
Group training workshop	51.2	41.5	3.9	3.4	3.40	0.73
Distribution of written materials	49.8	41.0	7.8	1.5	3.39	0.70

Scales: 4= strongly agree; 3= agree; 2= disagree; 1= strongly disagree

The results in Table 2 show a clear preference among extension workers for practical training approaches.

Discussion

The results in Table 1 show that 32.2% attended more than three training sessions, 10.2% attended two, 27.3% attended one, and 30.2% received no training at all. This means nearly 70% of extension workers had either no training or limited exposure. The absence of structured, regular in-service training poses serious challenges. This limits the workers' ability to stay current with new technologies, adapt to shifting environmental and market conditions, or provide context-specific solutions to farmers. Training enhances morale, promotes innovation, and bolsters institutional legitimacy. However, critics have pointed out several challenges. First, in many low-income settings, including Sudan, funding limitations make frequent training logistically difficult. Second, even when training is available, it may be overly theoretical or misaligned with local needs (30). In such cases, training does little to improve field performance and can even create frustration among staff. Furthermore, temporary donor-

led programs often fail to establish sustainable capacity-building systems. As a result, extension workers cycle through short-term workshops without long-term skill accumulation or follow-up. Some caution against overemphasizing formal training at the expense of informal, experience-based learning (26) argued that peer exchange, field-based experimentation, and mentorship can be as valuable as classroom instruction. They stressed the importance of blending formal and informal methods to create adaptive learning systems suited to local realities. A hybrid approach appears most viable. This includes periodic, targeted training that addresses practical field issues, coupled with ongoing mentorship, community feedback mechanisms, and opportunities for experiential learning. When designed in a participatory manner, such systems can balance resource constraints with the need for continuous improvements. In Sudan, building such a system requires aligning training design with real field conditions, ensuring equitable access, and embedding learning into the daily workflows of extension staff. Without these steps, efforts to strengthen agricultural extension remain fragmented and ineffective.

The findings in Table 2 show that monitoring and evaluation (mean = 3.65) and field demonstrations (mean = 3.64) emerged as the most favored methods. This suggests a strong inclination toward experiential, hands-on learning. Such methods allow workers to observe real-time processes, interact with farmers in natural settings, and immediately apply what they have learned. They also promote iterative learning and contextual adaptation, which are vital in the varied and unpredictable environments of rural Sudanese society. Field-based techniques like demonstrations provide more than knowledge transfer. They also foster credibility and trust. Farmers are more likely to engage with extension workers who can show results in practice rather than discuss them theoretically (24). Similarly, monitoring and evaluation—when participatory—empower workers to reflect on their activities, identify gaps, and improve service delivery in real time (25). Conversely, traditional formats such as printed manuals or centralized workshops were rated lower. This aligns with previous findings from Uganda and Ethiopia, where centralized training often failed to accommodate local language, literacy levels, and agro-ecological conditions (26). These methods are also less interactive and do not always provide opportunities for critical thinking or problem-solving. There are trade-offs. Practical methods such as field demonstrations require more logistical coordination, time, and resources. They demand access to land, inputs, and sometimes transport—challenges that many extension systems, particularly in Sudan, struggle to meet. Moreover, without strong facilitation skills, demonstrations can turn into passive show-and-tell sessions rather than opportunities for two-way learning.

Workshops and written materials, on the other hand, are easier to standardize and scale. They may be appropriate for delivering foundational knowledge or reaching large groups quickly. But they should not be the default. As (30) argued, training models must reflect the realities and preferences of the frontline workforce. Ignoring these preferences results in disengagement, weak retention, and poor application of knowledge in the field.

The most effective training systems combine multiple formats. A hybrid approach that integrates field demonstrations, participatory monitoring, targeted workshops, and follow-up mentoring can balance scale with quality. Such a model allows for both foundational Knowledge and context-specific adaptation, which are essential components for effective agricultural extension in vulnerable contexts. The study shows that many agricultural extension workers in Gezira, Sinnar, and Gedarif states have limited access to training opportunities, which affects their ability to perform effectively. Participatory training methods, particularly monitoring and evaluation and field demonstrations, emerged as the most preferred methods because of their practical relevance and impact. However, the current training systems often fail to reflect these preferences, highlighting the need for a shift toward more responsive and field-oriented approaches. Additionally, respondents reported low awareness and limited practical experience with participatory extension methods, underlining the need for structured programs that build communication, planning, and problem-solving skills. These findings support the creation of targeted, participatory training models that align with extension workers' needs and enhance the effectiveness of agricultural service delivery.

Conclusions

This study concludes that while agricultural extension workers are vital to knowledge transfer and rural development, many lack adequate and ongoing training. Addressing this gap requires structured, participatory training programs that prioritize practical, relevant content aligned with real field conditions. Assessing the specific needs and working environments of extension personnel is critical to improving performance. Non-technical factors like transportation, fair compensation, and infrastructure also significantly influence motivation and effectiveness. Training efforts should be informed by social and economic research to ensure they address actual challenges faced in rural contexts. Introducing new responsibilities without proper preparation reduces impact, making continuous professional development essential. A well-supported extension system, built on participatory principles and responsive to local realities, will be better equipped to address the evolving demands of agriculture in Sudan.

Conflict of interest: The authors hereby declare that there is no conflict of interest.

Data availability statement: The authors confirm that the datasupporting the findings of this

study are available within the article.

References:

1. World Bank, (2022). Sudan Economic Monitor: Toward Sustainable Recovery. https://www.worldbank.org
2. FAO (2022). Sudan Country Profile. Food and Agriculture Organization of the United Nations. http://www.fao.org/countryprofiles/index/en/?iso3=SDN
3. Pretty, J. (1995). Participatory learning for sustainable agriculture. World Development, 23(8): 1247-1263. https://doi.org/10.1016/0305-750X(95)00046-F
4. Osman, A., Elhaj, A., & Idris, H. (2023). Extension Workers' Perceptions of Participatory Training in Gezira, Sudan. Journal of Agricultural Extension, 21(1): 45-60.
5. Mutasa, M., & Muchabaiwa, L. (2021). Farmer Field Schools and Climate Resilience in Zimbabwe. African Journal of Rural Development, 15(2): 88-105.
6. Chinseu, E., & Banda, R. (2020). Participatory Extension Approaches in Southern Africa. Extension Farming Systems Journal, 12(4): 132-146.
7. Salih, O., Hassan, M., & Elhadi, M. (2021). Social Cohesion through Participatory Training in Sudan. Journal of Social Agriculture, 8(1): 21-34.
8. Elhag, M. (2016). Agricultural extension in Sudan: Challenges and prospects. https://doi.org/10.1080/09718923.2016.11906813
9. Kumar, S., & Nair, S. (2020). Gender Equity in Agricultural Extension: Lessons from Ethiopia and Kenya. Gender, Technology and Development, 24(1): 3-19. https://doi.org/10.1080/09718524.2020.1700223
10. Wanjiku, K., Mwangi, M., & Mwangi, W. (2019). Youth Engagement in Participatory Agricultural Training. Journal of Development Studies, 45(5): 523-538. https://doi.org/10.1080/00220388.2019.1584210
11. Davis, K. & Sulaiman, R. (2014). The "New Extensionist": Core Competencies for Individuals. https://www.g-fras.org/en/component/phocadownload/category/6-gfras-publications.html?download=358:the-new-extensionist-core-competencies-for-individuals
12. Abdelrahman, S., Osman, M., & Mohamed, T. (2020). Fragmentation in Agricultural Extension Services: The Sudanese Experience. Development Policy Review, 38(4): 453-469.
13. UNDP (2022). Enhancing Participatory Agricultural Extension for Sustainable Development in Sudan. United Nations Development Programme Report. https://www.undp.org/publications/sudan-agricultural-extension
14. Nhamo, L., Chikozho, C., & Makombe, K. (2021). Institutional Barriers to Scaling

Participatory Extension in Sub-Saharan Africa. Agriculture and Human Values, 38(1): 79-93.

15. Ali, R., & Ahmed, M. (2021). Gender and Participatory Agricultural Training in Sudan: Barriers and Opportunities. Gender, Technology and Development, 25(1): 83-99.

16. Eisa, M., Abdalla, M., & Nour, A. (2019). Enhancing Women's Participation in Agricultural Extension in Sudan. Journal of Rural Studies, 67: 54-63. https://doi.org/10.1016/j.jrurstud.2019.01.004

17. Njuki, J., Kaaria, S., & Sanginga, P. (2020). Gender Responsive Agricultural Extension in East Africa. Agricultural Systems, 178:102730. https://doi.org/10.1016/j.agsy.2019.102730

18. Elzaki, M., & Mohamed, T. (2022). Capacity Building Needs for Extension Workers in Sudan. Journal of Agricultural Education and Extension, 28(2): 150-165. https://doi.org/10.1080/1389224X.2022.2053678

19. Omer, A., Ali, H., & Suliman, M. (2021). Training-of-Trainers Approach in Agricultural Extension: Sudanese Experience. International Journal of Agricultural Extension, 29(1): 23-38. https://doi.org/10.1080/01587919.2021.1881923

20. Mahmoud, H., & Salih, I. (2019). Coordination Challenges in Sudanese Agricultural Extension. African Journal of Agricultural Research, 14(6): 259-271. https://doi.org/10.5897/AJAR2018.13213

21.Yagoub, S., & Musa, K. (2018). Participatory Extension for Climate Change Adaptation in Sudan. Climate and Development, 10(7): 627-636. https://doi.org/10.1080/17565529.2017.1329605

22. Rogers, E. M. (2003). Diffusion of Innovations (5th ed.). Free Press, New York. ISBN: 0743222091

23. Chambers, R., (1994). The origins and practice of participatory rural appraisal. World Development, 22(7): 953–969. https://doi.org/10.1016/0305-750X(94)90141-4

24. Davis, K., Mekonnen, D., Spielman, D., & Ameyaw, L., (2023). Participatory approaches in extension reform. Journal of Agricultural Education and Extension, 29(1): 17–33.

25. Chipeta, S., Christoplos, I., & Katz, E., (2020). Common framework on agricultural extension. Global Forum for Rural Advisory Services (GFRAS).

26. Sulaiman, R., Hall, A., & Raina, R., (2012). The apparent and hidden impacts of agricultural research: What do we learn from impact studies? Agricultural Systems, 108: 76–82.

27. Spielman, D., Ekboir, J., & Davis, K., (2011). The art and science of innovation systems

inquiry: Applications to Sub-Saharan African agriculture. IFPRI.

28. Prajapati, C.S., Verma, A., Sharma, R., & Kumar, M., (2025). Impact of participatory training on extension service delivery. International Journal of Rural Studies, 41(1): 28–42.

29. Rahman, S., & Yousif, M., (2016). Reforming agricultural extension in Sudan. Sudan Journal of Development Studies, 9(3): 105–122.

30. Zhang, L., & Li, J., (2020). Participatory training and knowledge sharing in Chinese SMEs. Journal of Workplace Learning, 32(4): 289–304.

31. Abdalla, O. A., & Elamin, M. A. (2018). Extension workers' perceptions towards participatory training in Sudan. Annals of Operations Research, 270(1-2): 83-95.

32. World Bank. (2017). Sudan Country Agricultural Policy Review. https://openknowledge.worldbank.org/handle/10986/28850

33. Pretty, J., & Ward, H. (2001). Social capital and the environment. World Development, 29(2): 209-227. https://doi.org/10.1016/S0305-750X(00)00098-X

34. Chambers, R. (1997). Whose Reality Counts? Putting the First Last, Intermediate Technology, London. https://doi.org/10.3362/9781780440453.000

35. Elhaj, A., & Mohamed, E. (2022). Inclusion of Marginalized Groups in Sudanese Agricultural Extension. International Journal of Agricultural Sustainability, 20(3): 215-230. https://doi.org/10.1080/14735903.2022.2045678

36. Abdi O. A., Glover E. K., & Luukkanen O. (2013) Causes and Impacts of Land Degradation and Desertification: Case Study of the Sudan. International Journal of Agriculture and Forestry, 3(2): 40-51. DOI: 10.5923/j.ijaf.20130302.03.

37. Mirghani, A. M., Elhaj, T. S., & Ahmed, A. (abbrev. for Adam), (2001). Socio-economic impact study of the pilot program at Al Hakam: Raising productivity through broadening farmers' choice on farm systems and water management. Sudan Gezira Board.

38. Technical Report, (2010), The constraints of rain-fed sector. Department of rain-fed sector, Sinnar State Ministry of Agriculture, Animal wealth and irrigation.

39. Abu Adil, H. Y. (2004). The Economics of Sesame Production in Gedarif Mechanized Rainfed Sector. M. Sc. Thesis, Department of Agricultural Economics, Faculty of Agriculture.