Identification of Nutrition-Sensitive Agriculture (NSA) Knowledge gaps in the Integration of Nutrition into Training by Agricultural Extension Advisory Services (EAS) Providers in India

Shirisha Junuthula [1, 2,*], Veenita Kumari [1], Chittur Srinivasan [2]

[1]Centre for Gender in Agriculture, Nutritional Security and Urban Agriculture, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, INDIA

[2]School of Agriculture, Policy and Development, University of Reading, Whiteknights, Reading RG6 6EU, United Kingdom

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*Corresponding author Contact email: siriinscience@gmail.com, Shirisha.Junuthula@tufts.edu (SJ); veenita.k@manage.gov.in (VK); c.s.srinivasan@reading.ac.uk (CS)

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Abstract:

Extension Advisory Service (EAS) providers, who are mostly extension staff of agriculture departments in developing countries, can serve as key agents of change in the development of nutrition-sensitive agriculture (NSA). However, the conventional knowledge domains and mandates of EAS staff are generally confined to production practices involving the use of inputs and new technologies to improve crop productivity. The potential role of EAS staff in promoting NSA may be hampered by their lack of knowledge of what NSA involves. We develop a standardised and validated instrument to assess the knowledge of EAS staff on different dimensions of NSA and their training needs. A survey of EAS staff in India using the instrument highlights the significant knowledge gaps of EAS staff on NSA. We also find that there are significant differences in the knowledge levels of EAS staff with and without NSA training. We show that NSA training based on a systematic assessment of knowledge gaps can strengthen the capacity of EAS staff to bring about the nutritionally sensitive transformation of agriculture in developing country contexts.

Key words: Agriculture, Assessment, Dimensions, Extension staff, Knowledge, Nutrition-Sensitive Agriculture (NSA), Training.

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1 Introduction

The development of nutrition-sensitive agriculture (NSA) is seen as an important priority for agricultural development to combat the incidence of malnutrition in rural areas and to address the agriculture-nutrition disconnect observed in many developing country contexts. NSA is a food-based approach to agricultural development that puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies (FAO, 2014). Making agriculture more nutrition-sensitive requires a change in the way of thinking, planning and implementing agricultural development programmes and requires partnership among a spread of stakeholders from multiple sectors. It also requires identifying critical entry points where nutrition goals are often incorporated into agro-food systems (Jaenicke and Virchow, 2013).

Extension Advisory Service (EAS) staff, with their long tradition of close links with the farming community, can potentially serve as key agents of change in bringing about the nutritionally sensitive transformation of agriculture. However, their conventional knowledge domains and mandates tend to focus almost exclusively on crop production and the use of new technologies to increase agricultural productivity. The NSA knowledge gaps of EAS staff may hamper their ability to contribute to the development of NSA. There is an urgent need to embed NSA concepts in the mandates of EAS staff. This requires the systematic assessment of their knowledge gaps related to NSA and targeted training programmes for capacity building to enable them to act as change agents for the nutritionally sensitive transformation of agriculture. This study attempts to develop a standardised scale for assessing the knowledge gaps of EAS staff in relation to NSA that can be used in different developing country contexts. The identification of knowledge gaps related to NSA can be useful in the capacity development of EAS staff for NSA interventions. We demonstrate the use of the scale through an application to a sample of EAS staff in India. Our results highlight the dimensions of NSA along which knowledge gaps are the largest. Our results also show that NSA training can be effective in bridging these knowledge gaps.

1.1 Previous Literature

1.1.1 Nutrition-Sensitive Agriculture

The concept of nutrition-sensitive interventions or programs is the need to prevent malnutrition and noncommunicable diseases worldwide. Nutrition-sensitive interventions or programs were defined as “Those that address the underlying determinants of fetal and child nutrition and development, food security; adequate caregiving resources at the maternal, household and community levels; and access to health services and a safe and hygienic environment and incorporate specific nutrition goals and actions" (Marie T. Ruel and Alderman, 2013). Agriculture has greater potential by providing farm income, and food prices will be maintained by steadiness between supply and demand, more nutritious crop availability and women's empowerment (Heckert, Olney and Ruel, 2019; Margolies *et al.*, 2023). There is a need to rethink that the linkage between agriculture and nutrition is not separated, as food production is not solely a function of agriculture but is translated into fruitfulness in reducing nutritional problems and improving nutritional status(Masset *et al.*, 2012).

Moreover, nutrition-sensitive agriculture (NSA) is a food-based approach to agricultural development that puts nutritionally rich foods(Yu and Tian, 2018), dietary diversity and food fortification(Masset *et al.*, 2012; Maluf *et al.*, 2015; Taquette and Minayo, 2015; Yu and Tian, 2018) at the heart of overcoming malnutrition and micronutrient deficiencies(FAO, 2014; Rafanomezantsoa *et al.*, 2022). Making agriculture more nutrition-sensitive requires a replacement way of thinking, planning, implementing, and partnering because of the active engagement of a spread of stakeholders from multiple sectors (Haghparast-Bidgoli *et al.*, 2019). The former nutrition-specific approaches are not able to address the persistent challenges of malnutrition(Bhutta *et al.*, 2013); in this regard, the involvement of multiple sectors and stakeholders that complement nutrition-sensitive approaches is needed(Marie T. Ruel and Alderman, 2013; Hodge *et al.*, 2015; Adeyemi *et al.*, 2022). These approaches aid in policies of macrolevel, household level and individual level factors of improved nutrition(Pingali *et al.*, 2019). It also requires identifying critical entry points where nutrition goals are often incorporated into agro-food systems(Jaenicke and Virchow, 2013). Integrating NSA into EAS can help in tackling malnutrition problems at the farmer community level(Haghparast-Bidgoli *et al.*, 2019). To achieve food security and address malnutrition problems(Mekonnen *et al.*, 2022), EAS needs to be more carefully focused on the needs of rural communities(Nichols, 2022) and their nutritional health(Suvedi and Kaplowitz, 2016) because they reach and interact closely with farmers in different settings(Fanzo *et al.*, 2015).

1.1.2 EAS staff in agriculture – domains and mandates

The major function of extension staff is to deliver technical messages to individual and group farmers by visiting their locations or farming areas. They are also advised on agricultural development not limited to crops but also on overall input supply, processing and marketing, their implications and developing aspects for production, marketing and processing technology(Norton and Alwang, 2020).

The agriculture sector in India consists of a substantial extension network, which has many projects, programs, centers, services and models involved through government at various levels(Maffioli *et al.*, 2023). This leads to heavy responsibility for extension advisory services (EAS), which need coordination among many stakeholders(Ogutu *et al.*, 2020) and key actors with assurance of program quality and implementing policy objectives(Rukmani *et al.*, 2019).

In recent years, interest in leveraging agriculture to improve nutritional outcomes has increased, especially at the institutional level (Marie T. Ruel, Quisumbing and Balagamwala, 2018; Harris-Fry *et al.*, 2020). The implementation of NSA in rural areas is possible through the agency of EAS staff. There is global interest in leveraging better agriculture extension and advisory services as a basis of food and nutritional security. Connecting extension and rural advisory services with health has the potential to improve nutrition outcomes through diversification of agricultural production and the household level (e.g., greater incorporation of fruits and vegetables in diets). Agricultural extension and advisory workers are probably the best placed agents to help farmers achieve nutritional education through biofortification, farm schools, convergence of actors, participatory methodologies, and information communication technologies (ICTs).

1.1.3 Previous studies on the assessment of NSA knowledge and efforts made to sensitise EAS staff to NSA concerns

NSA is an effective approach that targets agriculture in the transition towards sustainable food systems and healthy diets(Marie T. Ruel and Alderman, 2013; Marie T Ruel, Quisumbing and Balagamwala, 2018), intended to maximise agriculture and nutrition linkage for food and nutritional security. It facilitates narrowing the gap between availability and accessible food and healthy, balanced and diversified food for all(Jaenicke and Virchow, 2013). NSA acts as a platform to deliver agriculture sectors, health, education, environment, and social protection to address the underlying determinants of nutritional problems of people (Margolies *et al.*, 2022). NSA often comprises nutrition-sensitive and nutrition-specific actions, and from the last decade, various institutions, organisations, and agencies at the regional, national and international levels have been involved in the research and scaling up of the NSA concept(Marie T Ruel, Quisumbing and Balagamwala, 2018). One such case is instrumental in stimulating new initiatives and investments through multiple agriculture-nutrition pathways for the adaptation of biofortified crops(Wambugu *et al.*, 2015; Heckert, Olney and Ruel, 2019). While the contribution to nutritional outcomes is growing, there are still limited efforts in the implementation and scale-up of NSA interventions(Nordhagen and Traoré, 2022), and the associated influential factors have been neglected(McDermott *et al.*, 2013; Margolies *et al.*, 2022). Enabling effective NSA actions contributed to maternal and child nutrition(Marie T. Ruel and Alderman, 2013; Dallmann *et al.*, 2022; Nguyen *et al.*, 2022), policy- and implementation-related factors, knowledge on nutrition, human and institutional capacity, financial resources contributing to commitments and the environment for translation actions impacting nutrition at multiple levels(Hodge *et al.*, 2015). Environmental enabling factors for NSA were identified(Van Den Bold *et al.*, 2015; Bird *et al.*, 2019; Aryeetey and Covic, 2020), providing an understanding of the NSA with political, socioeconomic, policy and institutional influencing factors for interventions; however, there are only a few reviews available about NSA implementation. Knowledge on influential factors of agriculture-nutrition and sustainable food systems and knowledge on NSA intervention-specific actions is extremely emerging but still paltry (McDermott *et al.*, 2013). To utilise the effectiveness and contribution of NSA, it is essential to understand not only the impact but also the contributing factors and knowledge gaps in the implementation and scale-up of NSA(Haghparast-Bidgoli *et al.*, 2019; Turner *et al.*, 2022). The project outcomes and investments interplayed with intervention specific, local, environmental, and human factors.

The FAO has developed a compendium of indicators for nutrition-sensitive agriculture, the Compendium of Indicators(FAO, 2016), interventional options and measurement possible questions for nutrition-sensitive agriculture(FAO, 2017), and training material for extension staff available at www.fao.org, but these were helpful in measuring the NSA at the household or community level.

To our knowledge, past reviews and studies have not provided a consolidated overview of contributing factors and assessment of knowledge gaps. The major objective of this study is to assess the knowledge gaps in the context of NSA, which will help in the implementation of NSA and its related capacity building. A better understanding of knowledge gaps will aid in the decision-making of multiple actors in the design and implementation of NSA projects/programmes. The ultimate goal is to contribute to NSA implementation, which further reduces undernutrition in underdeveloped countries.

2 Methodology

We developed and standardised instrument for assessing the knowledge of EAS staff on nine key dimensions of NSA that covers the roles of (1) dietary diversity, (2) nutrition education, (3) kitchen and school gardens, (4) women farmers, (5) crop diversification, (6) crop value addition, (7) biofortification, (8) locally available nutritious crops in improving nutrition and an understanding of (9) the prevalence of malnutrition and nutritional status. The instrument had 95 questions (items) covering these nine dimensions of NSA. Using an expert consultation involving 16 experts in agriculture, nutrition, extension, and policy research, we validated the instrument using qualitative and quantitative methods and assessed its internal reliability. The experts were drawn from the Indian Institutes of Indian Council of Agricultural Research such as Krishi Vignan Kendra (KVKs) and State Agricultural Universities, National Institute of Rural Development and Panchayat Raj institutions (NIRD &PR), Extension Education Institutes (EEI), MS Swaminathan Foundation Research Foundation (MSSRF), Tata Institute of Social Sciences (TISS), and nongovernmental organisations (NGOs) from across India. The process adopted for developing the standardised instrument is summarised in **figure 1.**

Figure 1 Methodology adopted for the study. Source: Author's compilation, 2023

The nutrition and agriculture pathways, projects and interventions that showed positive impacts and were implementable by the Agricultural Extension were considered. Nine of the potential dimensions were finalised from a systematic literature search on NSA using Google Scholar, ScienceDirect, Scopus and research gate. Approximately 43 studies were found to be suitable with the key words. After going through the content, 27 studies were incorporated into the dimension's finalisation listed below **in Table 1**.

Table 1 Important dimensions of nutrition-sensitive agriculture

Dimension	**Reference**
Importance of Dietary Diversity	(Marquis *et al.*, 2018; Bird *et al.*, 2019; Sassi, 2019; Verger *et al.*, 2019; Margolies *et al.*, 2022)
Nutrition Education	(Hodge *et al.*, 2015; Mangheni, Shimali and Kabahenda, 2016; Muehlhoff *et al.*, 2017; Osei *et al.*, 2017; Marquis *et al.*, 2018; Schreinemachers *et al.*, 2019)
Promotion of kitchen and school gardens	(Osei *et al.*, 2017; Schreinemachers *et al.*, 2017, 2019; van den Bold *et al.*, 2021; Margolies *et al.*, 2022)
Promotion of the role of women farmers	(Marie T Ruel and Alderman, 2013; Rukmani *et al.*, 2019)
Promotion of diversification of crops	(Marie T. Ruel and Alderman, 2013; Rukmani *et al.*, 2019; Sassi, 2019)
Promotion of value- added food products	(McDermott *et al.*, 2013; Mangheni, Shimali and Kabahenda, 2016; Marie T Ruel, Quisumbing and Balagamwala, 2018; Padulosi, Roy and Rosado-May, 2019; Sassi, 2019)
Promotion of biofortification	(McDermott *et al.*, 2013; Marie T Ruel, Quisumbing and Balagamwala, 2018; Yu and Tian, 2018; Gannon *et al.*, 2019; Ogutu *et al.*, 2020)
Locally available nutritious crops	(Cheng *et al.*, 2017; Padulosi, Roy and Rosado-May, 2019; Wesley *et al.*, 2019)
Malnutrition and nutritional indicators	(McDermott *et al.*, 2013; Salasibew *et al.*, 2019)

The scale was designed to enable the development of training programmes for EAS staff that are tailored to address their knowledge gaps on NSA. The 95 questions in the instrument elicited responses on a 5-point Likert scale with Strongly Disagree=1, Disagree =2, Neither Agree nor Disagree=3, Agree=4 and Strongly Agree=5 for positive items and reverse scoring for the negative items as Strongly Disagree=5, Disagree =4, Neither Agree nor Disagree=3, Agree=2 and Strongly Agree=1. Both positive and negative items were included to obtain a better understanding of the knowledge gaps of EAS on the NSA concept(Junuthula, Kumari and Srinivasan, 2022)

The instrument was then used for a survey of 100 randomly selected EAS staff from different geographical zones of India, 50 of whom had received training in NSA and 50 who had received no training in NSA. We tested for significant differences in knowledge levels along the nine NSA dimensions between trained and untrained EAS staff and assessed the determinants of NSA knowledge through regression analysis.

2.1 Ethical approval and informed consent

The Ethics Committee of the Institute of Agricultural Extension Management (MANAGE), India approved this study protocol (study ID: 01-2022; date: January 31, 2022). We followed the principles of anonymity, confidentiality, and informed consent. All 100 participants were given a full explanation over the phone call, and a description of the study purpose, scope and contribution was provided before proceeding with an informed consent form.

2.2 Sampling and conduct of the study

This study was conducted in India between September and November 2022. A purposive and snowball sampling procedure was adopted, and the agriculture EAS staff were contacted to participate in the present study. MANAGE, being a National Institute for capacity building of officers at the senior and middle levels in agriculture and allied activities, has a vast pool of data on the participants/trainees who had attended training programs in the past. From the MANAGE database, a list of participants who had attended training in the last two years, i.e., 2018-2020 were generated. The details, in particular the participant's contact number, mail ID, and corresponding address, were stored in a data repository for 2 years. Therefore, the participants list was taken to short list the respondents for the current study and contacted over phone and mails. The detailed sampling is depicted in **figure 2**.

Inclusion criteria: male and female EAS staff working in agriculture or allied sectors with farming communities and willingness to provide informed consent for taking part in the survey. Exclusion criteria: EAS staff who declined to take part in the survey or were not from agriculture and allied sectors or were not involved with the farming community in the field.

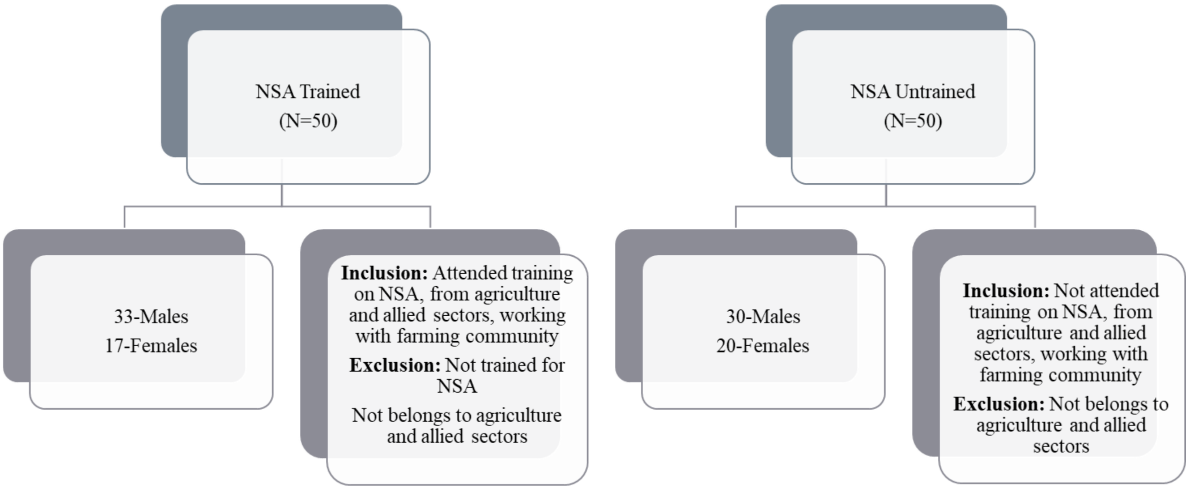

Figure 2 Sampling pattern of the study. NSA; Nutrition Sensitive Agriculture

2.3 Questionnaire and data collection

After the feedback and finalisation of the questionnaire. It is sent to the Agriculture Extension and Advisory Staff working in various sectors, such as Agriculture Extension Horticulture, Home Science, Veterinary, etc., and covering national institutions, state institutions, nongovernmental organisations (NGOs) and the private sector. To assess nutrition-sensitive agriculture, data from both NSA-trained and untrained extension staff were based on the data available at MANAGE, which covers respondents from Pan India.

The respondents were contacted by mailing online using Qualtrics to 50 NSA-trained and 50 untrained respondents. The Qualtrics link will be sent and given the time from September to November 2022. They were reminded through continuous calls and mails. The detailed questionnaire is available in the supplementary material.

2.4 Statistical analysis and scoring

Statistical analysis was carried out using R 4.1.0. We used Cronbach's alpha to assess the internal reliability of the responses, t tests to assess the differences in knowledge of different dimensions of NSA across groups of participants (including trained and untrained participants) and regression analysis to assess the drivers of knowledge levels. The responses of the survey participants were classified as representing high, medium or low knowledge of the different dimensions of NSA based on the mean and standard deviation (SD) of the responses, the classification followed as the mean+SD as high, Mean-SD as low, in between range as medium in the current study, but for the larger adaptation it can be used as 80% and above knowledge score as high, 50-80% as medium and below 50% as low for each dimension as well as for overall assessment of NSA.

3 Results:

The demographic profile of the EAS participants is summarised in **Table 2**. There was a larger proportion of men than women in both the trained and untrained categories of the respondents. This reflects the larger proportion of men with EAS in India (Ragasa, 2014). More than 50% had a graduate level of education or above. Respondents were 24-67 years of age with EAS experience ranging from 1 to 36 years, covering newcomers as well as highly experienced EAS staff.

Table 2 Characteristics of studied respondents (N= 100)

Variable	**Category/ Statistical Measure**	**Overall**	**Trained**	**Untrained**
		Frequency/Value	**Frequency/Value**	**Frequency/Value**
Gender	Male	63	33	30
	Female	37	17	20
Education	Above Postgraduate	29	19	10
	Postgraduate	54	22	32
	Graduate	16	8	8
	Below Graduate	1	1	0
Age	Mean	38.90	40.6	37.2
	Median	36.50	38.5	34
	Range	24-67	26-60	24-67
	SD	9.77	9.44	9.88
Experience	Mean	11.68	13.64	9.72
	Median	10	12	7
	Range	1-36	2-36	1-35
	SD	8.62	8.96	7.88

The internal consistency of the responses was calculated with Cronbach's alpha and is given in **Table 3**. The Cronbach's alpha values in the present study ranged between 0.60 and 0.80 for all 9 dimensions, which is acceptable (Augustine *et al.*, 2012; Sahoo *et al.*, 2019; da Silva, Piccoli and Pellanda, 2021; Khatti-Dizabadi *et al.*, 2022). After the validation from the experts, the respondents' Cronbach's alpha values also indicated the consistency for the use and standardisation of the developed scale. The highest internal validity was noticed for the promotion of value-added food products dimension, followed by the promotion of diversification of crops. This may reflect the academic knowledge of EAS staff and their mandates focused on increasing agricultural productivity. The lowest internal consistency was observed for biofortification. Biofortification has emerged as an instrument for improving nutrition relatively recently (Yu and Tian, 2018; Ogutu *et al.*, 2020), and it appears that few EAS staff have a good understanding of the importance of biofortification.

Table 3 Internal consistency of the developed scale.

Dimension	No. of Questions	Cronbach Alpha
Importance of Dietary Diversity	8	0.60
Nutrition Education	13	0.78
Promotion of Kitchen and School gardens	10	0.65
Promotion of the role of women farmers	10	0.68
Promotion of diversification of crops	11	0.73
Promotion of value-added food products	11	0.87
Promotion of biofortification	9	0.45
Locally available nutritious crops	12	0.60
Malnutrition and Nutritional Indicators	11	0.69

The detailed mean score for each dimension is given in **Table 4**. The knowledge on concepts and implementation aspects was assessed, and the knowledge scores of the trained participants were high when compared to the untrained participant scores in all 9 dimensions of the NSA. The trained participants' scores ranged from 63-85%, and for untrained staff, they ranged from 58-81%; specifically, in the dimensions of nutrition education, promotion of the role of women farmers, and promotion of value-added food products, trained staff scored more than 80%, whereas untrained staff scored 81% in the promotion of value-added food products dimension only. Training has a positive effect on NSA knowledge. Therefore, it can be suggested to implement NSA training on a regular basis. However, the trained staff could still perform better in other important dimensions, such as dietary diversity, kitchen and school gardens, crop diversification, promotion of biofortification, and promotion of locally available nutritious crops, which are essential for the translation from production-led extension to NSA. Malnutrition and nutritional indicators are also widely used at KVKs for measuring the nutritional status of households (Timler *et al.*, 2020) and farming communities to determine the impact of nutritional gardens and other crops (Masset *et al.*, 2012; Estrada-Carmona *et al.*, 2020); trained staff scored approximately 73%, and untrained staff scored approximately 68%. The Indian government is largely investing in biofortified varieties as a solution for malnutrition; hence, disseminating knowledge for EAS to convince the farming community for adaptation is vital. The importance of including nutrition in informal training of extension staff is crucial, but the barriers of training materials, costs, local language, access and dissemination, multiple responsibilities and tasks also need to be considered(Hodge *et al.*, 2015).

Table 4 Dimensionwise knowledge mean scores of the respondents.

Dimension	Maximum Score	Trained Scores Average	SD	Untrained Scores Average	SD	Total Scores Average	SD
Importance of Dietary Diversity	40	31.22	±3.29	29.62	±3.91	30.42	±3.69
Nutrition Education	65	53.48	±5.38	51.72	±6.88	52.6	±6.21
Promotion of Kitchen and School gardens	50	37.06	±4.87	35.6	±5.51	36.33	±5.23
Promotion of the role of women farmers	50	40.38	±4.43	39.12	±5.36	39.75	±4.93
Promotion of diversification of crops	55	42	±5.15	40.92	±6.05	41.46	±5.62
Promotion of value-added food products	55	46.82	±5.77	44.34	±7.08	45.58	±6.55
Promotion of biofortification	45	28.7	±4.60	26.18	±4.51	27.44	±4.71
Locally available nutritious crops	60	44.24	±4.99	43.16	±5.25	43.7	±5.12
Malnutrition and Nutritional Indicators	55	40.06	±5.42	37.48	±6.09	38.77	±5.88

A t test was performed to determine the difference in the trained and untrained respondents' responses/scores and is presented **in Table 5**. There was a significant difference between both groups for the dimensions of importance of dietary diversity (P=0.02927), promotion of biofortification (P=0.0067), malnutrition and nutritional indicators (P=0.0275) at the 95% confidence level of interval, and the overall knowledge gap was also significant (P=0.03042). The differences in the rest of the dimensions were not statistically significant.

Table 5 Comparison between the trained and untrained respondents for the NSA dimensions

Dimension	**P Value**	**Interpretation**
Importance of Dietary Diversity	0.02927	*
Nutrition Education	0.1575	Ns
Promotion of Kitchen and School gardens	0.1636	Ns
Promotion of the role of women farmers	0.2032	Ns
Promotion of diversification of crops	0.3389	Ns
Promotion of value-added food products	0.05792	Ns
Promotion of biofortification	0.006787	**
Locally available nutritious crops	0.2941	Ns
Malnutrition and Nutritional Indicators	0.0275	*
Overall	0.03042	*

*-P<0.5 **-P<0.01 Ns- Not significant

Regression analysis was used to determine the effect of dependent variables such as training, age, gender, education, and experience on NSA knowledge, as presented in **Table 6**. Among all the independent variables, the educational levels of postgraduates (P=0.0007) and above postgraduates (P=0.022) showed significant differences. The rest of the independent variables did not show any effect on the knowledge scores of the respondents on NSA.

Table 6 Regression analysis for training, age, gender, education, and experience on NSA knowledge

Variable	Estimate	SE	t value	p value	Interpretation
Intercept	396.353	30.678	12.92	<0.001	
Trained	11.499	7.433	1.547	0.125	Ns
Age	-1.033	1.035	-0.998	0.320	Ns
Gender	-2.365	7.709	-0.307	0.759	Ns
Education					
Graduate	-15.817	36.138	-0.438	0.662	Ns
Postgraduate	-40.407	11.64	-3.471	0.0007	***
Above Postgraduate	-19.992	8.628	-2.317	0.022	*
Experience	1.118	1.151	0.971	0.333	Ns

*-P<0.5 ***-P<0.001 Ns- Not significant

The association between the dimensions based on NSA knowledge is calculated and presented in **Table 7**. The correlation coefficients mean scores were significant for all the dimensions at the 5% level. The positive association among the dimensions shows the interrelation of dimensions, which is crucial for capacity building to prepare further training topics based on the least scored dimensions.

Table 7 Association between Dimensions (Correlation coefficients using means)

S.No	**Dimension**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Importance of Dietary Diversity	1	0.65	0.56	0.63	0.42	0.49	0.36	0.43	0.47
2	Nutrition Education	0.65	1	0.56	0.58	0.51	0.57	0.24	0.48	0.45
3	Promotion of Kitchen and School gardens	0.56	0.56	1	0.57	0.54	0.66	0.47	0.67	0.54
4	Promotion of the role of women farmers	0.63	0.58	0.57	1	0.52	0.66	0.4	0.61	0.61
5	Promotion of diversification of crops	0.42	0.51	0.54	0.52	1	0.55	0.35	0.51	0.39
6	Promotion of value-added food products	0.49	0.57	0.66	0.66	0.55	1	0.47	0.75	0.65
7	Promotion of biofortification	0.36	0.24	0.47	0.4	0.35	0.47	1	0.45	0.59
8	Locally available nutritious crops	0.43	0.48	0.67	0.61	0.51	0.75	0.45	1	0.64
9	Malnutrition and Nutritional Indicators	0.47	0.45	0.54	0.61	0.39	0.65	0.59	0.64	1

All correlation coefficients are significant at 5%

Total scores were obtained by combining all the responses of 95 questions by the respondents for the 9 dimensions. The comparison between NSA-trained respondents and untrained respondents was noticed to be significant, as presented in **table 8**. NSA-trained respondents scored better in the NSA knowledge scores; therefore, training/capacity building will enhance the knowledge of EAS staff and contribute to the implementation and scale-up of NSA in India.

Table 8 Comparison between trained and untrained based on NSA knowledge.

Based on training	**Mean Values**		**t value**	**p value**
	Trained	**Untrained**		
	3.81	3.64	2.26	0.025*

* $p < 0.05$

Similarly, the mean values are calculated, and the gender difference across the dimensions for the untrained staff is given in **table 9**. The scores among the promotion of the role of women farmers are significant, and other dimensions are not significant.

Table 9 Gender difference between untrained respondents for NSA dimensions

Dimension	**Mean Values**		**t value**	**p value**
	Males	**Females**		
Importance of Dietary Diversity	3.79	3.64	1.10	0.276
Nutrition Education	4.08	3.90	1.32	0.192
Promotion of Kitchen and School gardens	3.56	3.55	0.05	0.959
Promotion of the role of women farmers	4.12	3.77	2.50	0.015*
Promotion of diversification of crops	3.70	3.72	0.11	0.908
Promotion of value-added food products	4.13	3.96	0.98	0.328
Promotion of biofortification	2.81	2.97	1.09	0.277
Locally available nutritious crops	3.65	3.56	0.71	0.480
Malnutrition and Nutritional Indicators	3.56	3.30	1.69	0.096

* $p < 0.05$

The knowledge and involvement of the EAS trend was high among the trained respondents, and it can be inferred that their knowledge and awareness were greater than those of the untrained respondents. Although gender participation was less from the female staff, the gender difference was observed to be not significant among the trained staff and presented in **table 10**.

Table 10 Gender difference between trained respondents for NSA dimensions

Dimension	Mean Values		t value	p value
	Males	Females		
Importance of Dietary Diversity	3.92	3.89	0.28	0.776
Nutrition Education	4.16	4.08	0.56	0.578
Promotion of Kitchen and School gardens	3.71	3.70	0.10	0.914
Promotion of the role of women farmers	3.97	4.07	0.70	0.484
Promotion of diversification of crops	3.81	3.81	0	1
Promotion of value-added food products	4.14	4.31	1.12	0.268
Promotion of biofortification	3.17	3.19	0.11	0.907
Locally available nutritious crops	3.62	3.71	0.84	0.405
Malnutrition and Nutritional Indicators	3.55	3.68	0.91	0.365

The obtained NSA knowledge scores are classified in **Figure 3**. High knowledge scores were noticed for 10-21%, medium for 63-80% and low for 9-20% of the respondents. Therefore, there is a clear indication that Agricultural EAS staff is not equipped with the NSA and its components among all the dimensions in India. Thus, respondents with low and medium scores need to be trained for the implementation of NSA. The overall NSA knowledge scores from pan India were low (13%), medium (73%) and high (14%). Hence, there is an emerging need for capacity building in the dimensions of NSA for EAS of India.

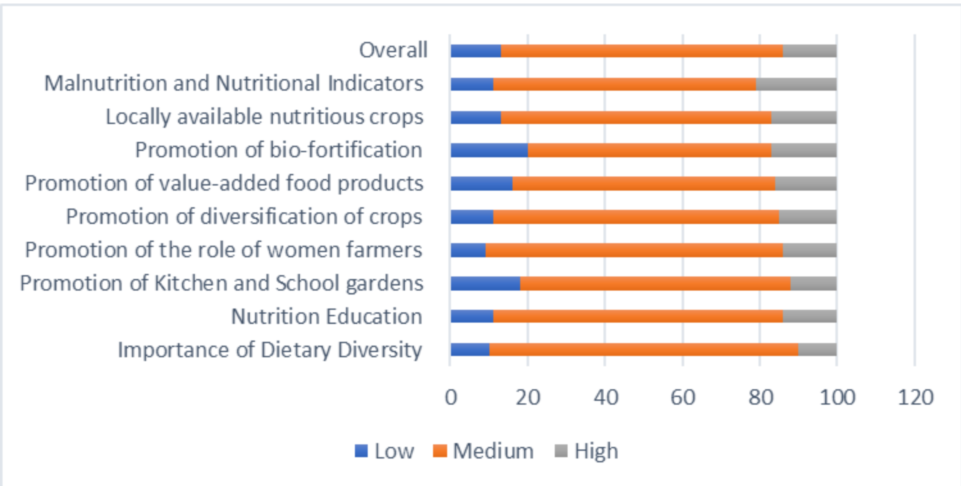

Figure 3 Classification of respondents based on mean ± SD (N=100).

4 Discussion and Conclusion

We demonstrate the development and use of a standardised and validated instrument for assessing the NSA knowledge of EAS staff along its key dimensions. This scale can be readily adapted for use in different developing country contexts. This instrument can make an important contribution to capacity building for EAS staff for nutritionally sensitive transformation of agriculture in developing countries.

The survey of EAS staff in India using this instrument shows how the conventional knowledge domains and mandates of EAS staff may leave them with significant knowledge gaps for acting as change agents for NSA. Our results also show that systematic assessment of training needs and the development of carefully crafted training programmes can be effective in bridging knowledge gaps. There is clear evidence that trained participant scores in knowledge were higher than those of untrained staff. However, there is still scope for regular training on NSA. Our results highlight the need for embedding NSA in mandates and capacity building programmes for EAS staff in developing countries.

The agriculture-nutrition impact pathways are crucial for nutrition-sensitive agriculture (NSA), which contributes to improving nutritional outcomes and eradicating nutritional problems in farming communities(Brar *et al.*, 2020). However, to utilise NSA training results, it is equally important to understand which dimensions or areas of NSA knowledge gaps existing in the EAS need to be identified. Evidence on identifying these knowledge gaps and important dimensions helps in the implementation and scaling-up of NSA in low- and middle-income countries (LMICs) is still limited(Marie T Ruel, Quisumbing and Balagamwala, 2018). To address this gap, we demonstrate the development and use of a standardised and validated instrument for assessing the NSA knowledge of EAS staff along its key dimensions. This scale can be readily adapted for use in different developing country contexts(Junuthula, Kumari and Srinivasan, 2022). This instrument can make an important contribution to capacity building for EAS staff for nutritionally sensitive transformation of agriculture in developing countries. Our metric will facilitate the design of capacity building and training programs for EAS workers to promote NSA. With the use of this scale, capacity building and training programs can be tailored to the specific knowledge gaps of EAS workers from different locations. Training needs identification will help in planning suitable training to translate agriculture into being more nutritionally sensitive at multiple levels and anticipate possible pitfalls in NSA implementation to reduce malnutrition in LMICs.

5 Study limitations

There is a limited amount of research on NSA assessment, which may hinder the development of evidence-based interventions. To our knowledge, this is the first study to assess and validate the NSA scale among the EAS staff of India. The present validation study has several limitations. We included only 100 participants due to time constraints. The study may need to be conducted with a larger and more representative sample of EAS staff to make a robust assessment of the knowledge gaps of EAS staff in relation to NSA.

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Supplementary material:

The detailed questionnaire is available at https://osf.io/2arp7/.

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