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

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29 **Abstract:**

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

43

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

46 **JEL Code: Q000**

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57 **1 Introduction**

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

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

84 **1.1 Previous Literature**

85 *1.1.1 Nutrition-Sensitive Agriculture*

86 The concept of nutrition-sensitive interventions or programs is the need to prevent malnutrition
87 and noncommunicable diseases worldwide. Nutrition-sensitive interventions or programs were
88 defined as “Those that address the underlying determinants of fetal and child nutrition and

89 development, food security; adequate caregiving resources at the maternal, household and
90 community levels; and access to health services and a safe and hygienic environment and
91 incorporate specific nutrition goals and actions” (Marie T. Ruel and Alderman, 2013).
92 Agriculture has greater potential by providing farm income, and food prices will be maintained
93 by steadiness between supply and demand, more nutritious crop availability and women’s
94 empowerment (Heckert, Olney and Ruel, 2019; Margolies *et al.*, 2023). There is a need to
95 rethink that the linkage between agriculture and nutrition is not separated, as food production
96 is not solely a function of agriculture but is translated into fruitfulness in reducing nutritional
97 problems and improving nutritional status(Masset *et al.*, 2012).

98 Moreover, nutrition-sensitive agriculture (NSA) is a food-based approach to agricultural
99 development that puts nutritionally rich foods(Yu and Tian, 2018), dietary diversity and food
100 fortification(Masset *et al.*, 2012; Maluf *et al.*, 2015; Taquette and Minayo, 2015; Yu and Tian,
101 2018) at the heart of overcoming malnutrition and micronutrient deficiencies(FAO, 2014;
102 Rafanomezantsoa *et al.*, 2022). Making agriculture more nutrition-sensitive requires a
103 replacement way of thinking, planning, implementing, and partnering because of the active
104 engagement of a spread of stakeholders from multiple sectors (Haghparast-Bidgoli *et al.*,
105 2019). The former nutrition-specific approaches are not able to address the persistent
106 challenges of malnutrition(Bhutta *et al.*, 2013); in this regard, the involvement of multiple
107 sectors and stakeholders that complement nutrition-sensitive approaches is needed(Marie T.
108 Ruel and Alderman, 2013; Hodge *et al.*, 2015; Adeyemi *et al.*, 2022). These approaches aid in
109 policies of macrolevel, household level and individual level factors of improved
110 nutrition(Pingali *et al.*, 2019). It also requires identifying critical entry points where nutrition
111 goals are often incorporated into agro-food systems(Jaenicke and Virchow, 2013). Integrating
112 NSA into EAS can help in tackling malnutrition problems at the farmer community
113 level(Haghparast-Bidgoli *et al.*, 2019). To achieve food security and address malnutrition
114 problems(Mekonnen *et al.*, 2022), EAS needs to be more carefully focused on the needs of
115 rural communities(Nichols, 2022) and their nutritional health(Suvedi and Kaplowitz, 2016)
116 because they reach and interact closely with farmers in different settings(Fanzo *et al.*, 2015).

117 ***1.1.2 EAS staff in agriculture – domains and mandates***

118 The major function of extension staff is to deliver technical messages to individual and group
119 farmers by visiting their locations or farming areas. They are also advised on agricultural
120 development not limited to crops but also on overall input supply, processing and marketing,

121 their implications and developing aspects for production, marketing and processing
122 technology(Norton and Alwang, 2020).

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

128 In recent years, interest in leveraging agriculture to improve nutritional outcomes has
129 increased, especially at the institutional level (Marie T. Ruel, Quisumbing and Balagamwala,
130 2018; Harris-Fry *et al.*, 2020). The implementation of NSA in rural areas is possible through
131 the agency of EAS staff. There is global interest in leveraging better agriculture extension and
132 advisory services as a basis of food and nutritional security. Connecting extension and rural
133 advisory services with health has the potential to improve nutrition outcomes through
134 diversification of agricultural production and the household level (e.g., greater incorporation
135 of fruits and vegetables in diets). Agricultural extension and advisory workers are probably the
136 best placed agents to help farmers achieve nutritional education through biofortification, farm
137 schools, convergence of actors, participatory methodologies, and information communication
138 technologies (ICTs).

139 ***1.1.3 Previous studies on the assessment of NSA knowledge and efforts made to sensitise***
140 ***EAS staff to NSA concerns***

141 NSA is an effective approach that targets agriculture in the transition towards sustainable food
142 systems and healthy diets(Marie T. Ruel and Alderman, 2013; Marie T Ruel, Quisumbing and
143 Balagamwala, 2018), intended to maximise agriculture and nutrition linkage for food and
144 nutritional security. It facilitates narrowing the gap between availability and accessible food
145 and healthy, balanced and diversified food for all(Jaenicke and Virchow, 2013). NSA acts as a
146 platform to deliver agriculture sectors, health, education, environment, and social protection to
147 address the underlying determinants of nutritional problems of people (Margolies *et al.*, 2022).
148 NSA often comprises nutrition-sensitive and nutrition-specific actions, and from the last
149 decade, various institutions, organisations, and agencies at the regional, national and
150 international levels have been involved in the research and scaling up of the NSA
151 concept(Marie T Ruel, Quisumbing and Balagamwala, 2018). One such case is instrumental in
152 stimulating new initiatives and investments through multiple agriculture-nutrition pathways for

153 the adaptation of biofortified crops(Wambugu *et al.*, 2015; Heckert, Olney and Ruel, 2019).
154 While the contribution to nutritional outcomes is growing, there are still limited efforts in the
155 implementation and scale-up of NSA interventions(Nordhagen and Traoré, 2022), and the
156 associated influential factors have been neglected(McDermott *et al.*, 2013; Margolies *et al.*,
157 2022). Enabling effective NSA actions contributed to maternal and child nutrition(Marie T.
158 Ruel and Alderman, 2013; Dallmann *et al.*, 2022; Nguyen *et al.*, 2022), policy- and
159 implementation-related factors, knowledge on nutrition, human and institutional capacity,
160 financial resources contributing to commitments and the environment for translation actions
161 impacting nutrition at multiple levels(Hodge *et al.*, 2015). Environmental enabling factors for
162 NSA were identified(Van Den Bold *et al.*, 2015; Bird *et al.*, 2019; Aryeetey and Covic, 2020),
163 providing an understanding of the NSA with political, socioeconomic, policy and institutional
164 influencing factors for interventions; however, there are only a few reviews available about
165 NSA implementation. Knowledge on influential factors of agriculture-nutrition and sustainable
166 food systems and knowledge on NSA intervention-specific actions is extremely emerging but
167 still paltry (McDermott *et al.*, 2013). To utilise the effectiveness and contribution of NSA, it is
168 essential to understand not only the impact but also the contributing factors and knowledge
169 gaps in the implementation and scale-up of NSA(Haghparsast-Bidgoli *et al.*, 2019; Turner *et*
170 *al.*, 2022). The project outcomes and investments interplayed with intervention specific, local,
171 environmental, and human factors.

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

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

184

185 **2 Methodology**

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



200

201 **Figure 1** Methodology adopted for the study. Source: Author’s compilation, 2023

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

208

209 **Table 1** Important dimensions of nutrition-sensitive agriculture

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

210

211 The scale was designed to enable the development of training programmes for EAS staff that
 212 are tailored to address their knowledge gaps on NSA. The 95 questions in the instrument elicited

213 responses on a 5-point Likert scale with Strongly Disagree=1, Disagree =2, Neither Agree nor
214 Disagree=3, Agree=4 and Strongly Agree=5 for positive items and reverse scoring for the negative
215 items as Strongly Disagree=5, Disagree =4, Neither Agree nor Disagree=3, Agree=2 and Strongly
216 Agree=1. Both positive and negative items were included to obtain a better understanding of the
217 knowledge gaps of EAS on the NSA concept(Junuthula, Kumari and Srinivasan, 2022)

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

223 **2.1 Ethical approval and informed consent**

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

229

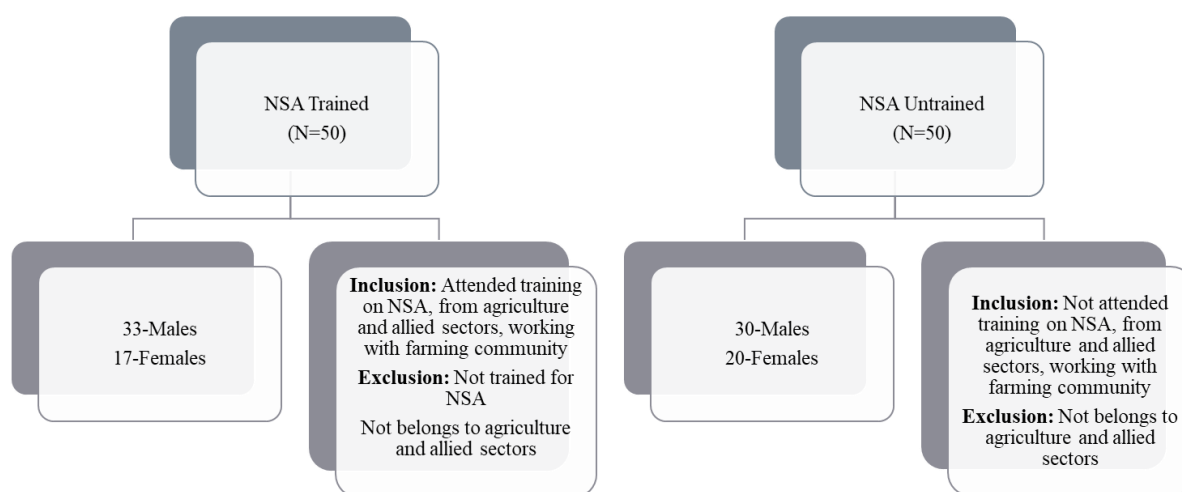
230 **2.2 Sampling and conduct of the study**

231

232 This study was conducted in India between September and November 2022. A purposive and
233 snowball sampling procedure was adopted, and the agriculture EAS staff were contacted to
234 participate in the present study. MANAGE, being a National Institute for capacity building of
235 officers at the senior and middle levels in agriculture and allied activities, has a vast pool of
236 data on the participants/trainees who had attended training programs in the past. From the
237 MANAGE database, a list of participants who had attended training in the last two years, i.e.,
238 2018-2020 were generated. The details, in particular the participant's contact number, mail ID,
239 and corresponding address, were stored in a data repository for 2 years. Therefore, the
240 participants list was taken to short list the respondents for the current study and contacted over
241 phone and mails. The detailed sampling is depicted in **figure 2**.

242 Inclusion criteria: male and female EAS staff working in agriculture or allied sectors with
243 farming communities and willingness to provide informed consent for taking part in the survey.

244 Exclusion criteria: EAS staff who declined to take part in the survey or were not from
245 agriculture and allied sectors or were not involved with the farming community in the field.



246

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

248

249 **2.3 Questionnaire and data collection**

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

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

260 **2.4 Statistical analysis and scoring**

261 Statistical analysis was carried out using R 4.1.0. We used Cronbach's alpha to assess the
 262 internal reliability of the responses, t tests to assess the differences in knowledge of different
 263 dimensions of NSA across groups of participants (including trained and untrained participants)
 264 and regression analysis to assess the drivers of knowledge levels. The responses of the survey
 265 participants were classified as representing high, medium or low knowledge of the different
 266 dimensions of NSA based on the mean and standard deviation (SD) of the responses, the
 267 classification followed as the mean+SD as high, Mean-SD as low, in between range as medium

268 in the current study, but for the larger adaptation it can be used as 80% and above knowledge
 269 score as high, 50-80% as medium and below 50% as low for each dimension as well as for
 270 overall assessment of NSA.

271

272 **3 Results:**

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

279 **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

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

292 **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

293

294 The detailed mean score for each dimension is given in **Table 4**. The knowledge on concepts
 295 and implementation aspects was assessed, and the knowledge scores of the trained participants
 296 were high when compared to the untrained participant scores in all 9 dimensions of the NSA.
 297 The trained participants' scores ranged from 63-85%, and for untrained staff, they ranged from
 298 58-81%; specifically, in the dimensions of nutrition education, promotion of the role of women

319 farmers, and promotion of value-added food products, trained staff scored more than 80%,
 320 whereas untrained staff scored 81% in the promotion of value-added food products dimension
 321 only. Training has a positive effect on NSA knowledge. Therefore, it can be suggested to
 322 implement NSA training on a regular basis. However, the trained staff could still perform better
 323 in other important dimensions, such as dietary diversity, kitchen and school gardens, crop
 324 diversification, promotion of biofortification, and promotion of locally available nutritious
 325 crops, which are essential for the translation from production-led extension to NSA.
 326 Malnutrition and nutritional indicators are also widely used at KVKs for measuring the
 327 nutritional status of households (Timler *et al.*, 2020) and farming communities to determine
 328 the impact of nutritional gardens and other crops (Masset *et al.*, 2012; Estrada-Carmona *et al.*,
 329 2020); trained staff scored approximately 73%, and untrained staff scored approximately 68%.
 330 The Indian government is largely investing in biofortified varieties as a solution for
 331 malnutrition; hence, disseminating knowledge for EAS to convince the farming community for
 332 adaptation is vital. The importance of including nutrition in informal training of extension staff
 333 is crucial, but the barriers of training materials, costs, local language, access and dissemination,
 334 multiple responsibilities and tasks also need to be considered (Hodge *et al.*, 2015).

335 **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

316

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

323 **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	*

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

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

330

331

332

333 **Table 6** Regression analysis for training, age, gender, education, and experience on NSA
 334 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

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

336

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

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346 **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

347 *All correlation coefficients are significant at 5%*

348

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

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358 **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*

359 * p < 0.05

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

363 **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

364 * p < 0.05

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

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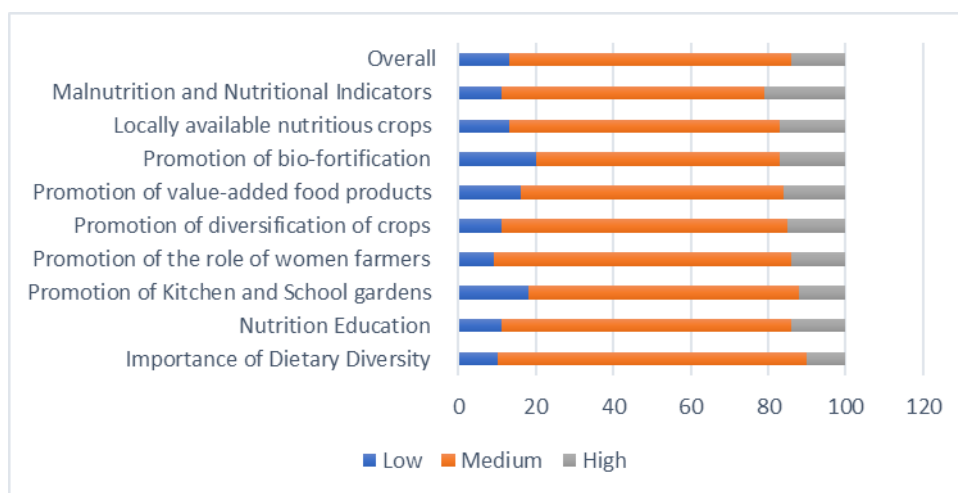
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373 **Table 10** Gender difference between trained respondents for NSA dimensions

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

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



381

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

383 **4 Discussion and Conclusion**

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

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

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

415 **5 Study limitations**

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

422

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432

433 **Supplementary material:**

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

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