Sustainable Food Connect
2025, Vol. 1, Cite as: doi:10.x/journal.x.x.x

SCIFINITI PUBLISHING

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Research Article

Exploring Neuromarketing Techniques for Advancing Sustainability in India's Food and Agribusiness Sector

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Abstract: Despite growing global interest, neuromarketing remains underutilized in India's agri-food sector. This study investigates the awareness, application, and potential of neuromarketing tools—such as EEG (Electroencephalography), eye-tracking, IAT, and VR/AR—in shaping sustainable consumer behavior in India. Respondents for the study were selected using purposive and snowball sampling techniques. While global corporations leverage neuroscience to refine marketing strategies, Indian agribusinesses and food startups often lack the awareness, infrastructure, and policy support to adopt such innovations. Using mixed methods and a sample of 120 participants for the quantitative survey and 12 experts for in-depth qualitative interviews, from marketing, academia, Fast-Moving Consumer Goods (FMCGs), and agri-businesses, the study reveals that only 27% are familiar with neuromarketing as a field, and a mere 14% report active implementation. Awareness and application are higher in metro-based food-tech startups and FMCGs, while traditional agri-businesses and policymakers show minimal engagement. Education and urban access strongly influence exposure to

neuromarketing. The findings highlight a significant urban–rural and disciplinary divide. The final prioritization highlights that accuracy and lack of bias emerged as the most critical factors influencing the adoption of neuromarketing tools for sustainable product marketing in India's agri-food sector. Among the application areas, advertising (weight = 0.610) and branding (weight = 0.271) emerged as the most influential domains, indicating where business decision-makers are most likely to leverage neuromarketing techniques to boost consumer engagement and advance sustainability-oriented strategies. Neuromarketing shows promise for promoting sustainable choices—like climate-resilient crops and eco-labels—by tapping into subconscious consumer responses. The study recommends policy interventions including academic integration, funding support, ethical frameworks, and public-private partnerships. By aligning neuromarketing with SDGs—particularly SDG 2, 4, and 12—this research positions it as a transformative tool for advancing sustainability and consumer-centric innovation in India's food and agribusiness sector.

Keywords: neuromarketing; agri-food sector; consumer behavior; sustainability marketing; EEG; eye tracking; food startups; sustainable consumption; Functional Magnetic Resonance Imaging (FMRI)

JEL Codes: Q13, Q18, M31, O33, I15, D91

Introduction

Neuromarketing, a concept introduced by Dutch organizational theorist Ale Smidts in 2002, offers a revolutionary approach to understanding consumer behavior by examining the neural and physiological processes underlying decision-making. Neuromarketing has emerged as a rapidly evolving interdisciplinary field, drawing upon insights from neuroscience, psychology, and marketing. Advanced methods such as EEG, Eye Tracking, Functional Magnetic Resonance Imaging (FMRI), and Galvanic Skin Response (GSR) are employed to identify subconscious responses and emotional stimuli that conventional approaches like surveys or focus groups may fail to capture [1,2].

Neuromarketing, a branch of neuroeconomics, offers practical insights into consumer decision-making processes. Over the past two decades, neuroeconomics has gained practical applications in consumer neuroscience and neuromarketing [3,4]. Businesses are now using neuroscience-based tools to improve branding, product innovation, advertising design, and customer engagement, especially in sectors like food and beverages where emotions significantly influence purchasing decisions [5,6].

Neuromarketing is gaining traction in agriculture and agribusiness, as it helps to understand how cognitive and emotional factors influence food preferences, sustainability perceptions, and consumption habits. This approach can design campaigns that not only increase sales but also encourage sustainable behaviors, such as promoting healthier options like millets over rice or locally produced foods, by appealing to both rational and subconscious drivers of choice [7].

Neuroscience advancements enable marketers to accurately measure consumer attention, emotional arousal, and memory retention [8]. These tools are used globally to evaluate responses to eco-friendly packaging, sustainability labels, farm-to-table branding, and health-focused messages. Neuro-based studies suggest visuals promoting nature, community well-being, and health benefits enhance emotional engagement and memory recall.

It augments traditional marketing by incorporating behavioural economics, cultural psychology, and consumer neuroscience, resulting in holistic, sustainability-oriented marketing frameworks. This interdisciplinary partnership improves product success while also supporting broader social objectives such as climate resilience, food sovereignty, and public health.

Problem Statement: Neuromarketing, a global marketing strategy, is underdeveloped in India's agri-food sector. Indian agribusinesses, food startups, and FMCG brands face challenges like low awareness, insufficient technical capacity and lack of validated models. The absence of empirical research, region-specific consumer insights, and regulatory frameworks further restricts its effective use. These gaps limit innovation in food marketing and hinder the sector's alignment with nutritional security, sustainability, and ethical consumption goals. Neuromarketing is gaining traction in India's agri-food business because to its ability to comprehend customer behaviour regarding nutrition, environmental responsibility, and ethical sourcing. It can encourage better diets, ecologically responsible choices, and local food systems through bridging the gap between consumer psychology and sustainable marketing, resulting in more sustainable production and consumption.

Therefore, this study seeks to assess the awareness and application of neuromarketing within India's agribusinesses, food startups, and FMCG companies, identify challenges and opportunities in employing neuroscience-based marketing strategies, and suggest recommendations for incorporating neuromarketing into sustainable food policies and consumer engagement.

By linking marketing strategies to subconscious cues that promote sustainable food choices—such as local foods, organic produce, or climate-smart grains like millets—this research aims to offer innovative solutions to encourage eco-friendly consumer behavior. It aligns with global sustainability goals for e.g., SDG 2(Zero Hunger), SDG 4(Quality Education), SDG 12(Responsible Consumption and Production) and India’s national priorities for food and nutritional security.

Ultimately, the research will contribute to the academic discourse on neuromarketing while offering practical, sustainability-focused insights for Indian marketers, agribusinesses, and policy-makers.

Methodology

This study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to examine the awareness, landscape, and application of neuromarketing within the Indian agri-food sector, with particular focus on its potential connection to sustainable marketing strategies. The descriptive study methodology mapped the understanding and status of neuromarketing techniques across agricultural stakeholders, while the

exploratory component investigated their potential to promote sustainable consumer behaviour and market growth.

Based on this methodology, the study sought to achieve a number of crucial objectives. The first goal was to identify and analyse the level of awareness and acceptance of neuromarketing among Indian agribusinesses and marketers. Second, it investigated the perceived benefits and constraints of using neuromarketing in this setting. Third, it investigated the ability of neuromarketing methods to match with sustainable food marketing and consumption objectives. Finally, the study sought to provide practical techniques for implementing neuromarketing into India's agri-food marketing practices in ways that promote corporate growth while also advancing sustainability goals.

The snowball sampling approach was used in this study to choose 120 participants for a quantitative survey and 12 experts for in-depth qualitative interviews, which included marketing professionals, FMCG companies, food—tech startups, researchers, academics in consumer behaviour, neuroscience, and food marketing, as well as industry specialists and policymakers working in sustainable food systems.

Primary data were collected using a semi-structured questionnaire and in-depth interviews. The questionnaire captured the respondents' familiarity with neuromarketing techniques such as EEG, eye-tracking, facial expression analysis, and GSR, along with their perspectives on how these tools affected marketing performance and consumer insight. In-depth interviews provided qualitative insights into industry-specific applications, implementation challenges, and the extent to which firms were integrating neuromarketing with sustainable branding and product development. Secondary data were collected from peer-reviewed journal articles, global market research reports by organizations such as Nielsen and Millward Brown, white papers by neuromarketing associations, company websites, policy documents, and published case studies on international best practices.

Data analysis involved both statistical and thematic techniques. Quantitative data were analyzed using SPSS, applying descriptive statistics such as percentages, frequencies, means, and cross-tabulation by education, industry segment, and regions. **Awareness Level,** Measured using Likert-scale items such as: "I am familiar with neuromarketing as a concept"; "I have heard of tools like eye-tracking, EEG, or facial coding"; Responses categorized as: *Not Aware*, *Partially Aware*, *Fully Aware*. ***Application Level:*** Binary and scale-based questions such as: "Has your organization used any neuromarketing tool in practice?" Frequency and type of use were also recorded.

Fuzzy AHP Equations and Formulas for Neuromarketing Adoption: Fuzzy AHP is a widely used MCDM method that effectively manages uncertainty and subjectivity in decision-making also recognized for its flexibility and applicability in real-world decision-making, particularly in situations where pairwise comparisons may be inconsistent [9,10,11]. The method of decomposing complex problems into hierarchical structures and incorporating fuzzy logic into expert judgments enables more precise prioritization of qualitative criteria (Chou, 2019), making it highly relevant in sustainability research (Calabrese, 2019), with applications in green supply chain management [12] and environmental assessment frameworks [13]. The study uses Fuzzy AHP to assess the factors influencing managers' willingness to adopt neuromarketing for sustainable product marketing in India's

agri-food sector. The methodology uses equations and formulas to calculate adoption criteria and alternatives, providing a basis for analyzing neuromarketing adoption. Below steps are followed:

1. Triangular Fuzzy Numbers (TFN): Triangular fuzzy numbers (TFN) were used following expert opinions with $\tilde{A} = (l, m, u)$, where l is the lower bound, m is the most likely (modal) value, and u is the upper bound. This representation allows incorporating vagueness in human judgments.

2. Construction of the Fuzzy Pairwise Comparison: criteria were collected from experts, and the fuzzy comparison matrix was constructed as:

$$\tilde{A} = [\widetilde{a_{ij}}] = [(l_{ij}, m_{ij}, u_{ij})]$$

The reciprocal property of fuzzy judgments was maintained as:

$$\widetilde{a_{ji}} = \left(\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{l_{ij}}\right)$$

3. Fuzzy Synthetic Extent Value Calculation: For each criterion iii, the fuzzy synthetic extent value was calculated using:

$$S_i = \frac{\sum_{j=1}^{n} \widetilde{a_{ij}}}{\sum_{i=1}^{n} \sum_{j=1}^{n} \widetilde{a_{ij}}}$$

4. Degree of Possibility: The degree of possibility was applied to compare fuzzy numbers. For two fuzzy numbers $\widetilde{A_1} = (l_1, m_1, u_1)$ *and* $\widetilde{A_2} = (l_2, m_2, u_2)$, the degree of possibility was computed as:

$$V(\tilde{A}_1 \geq \tilde{A}_2) = \begin{cases} 1, & \text{if } m_1 \geq m_2 \\ 0, & \text{if } l_2 \geq u_1 \\ \frac{l_2 - u_1}{(m_1 - u_1) - (m_2 - l_2)}, & \text{otherwise} \end{cases}$$

5. Derivation and Normalization of Fuzzy Weights: The fuzzy weights of criteria were defuzzified using the centroid method:

$$w_i = \frac{l_i + m_i + u_i}{3}$$

The weights were then normalized as:

$$w_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$$

6. Consistency Check: To ensure logical consistency in the pairwise comparison matrix, the fuzzy consistency ratio (CR) was calculated as:

$$CR = \frac{CI}{RI}$$

where *CI* represents the consistency index and *RI* is the random index. The matrix was considered consistent if *CR<0.1*

Wherever relevant, inferential statistical techniques were employed to explore the relationships between variables. The qualitative data collected through interviews were transcribed, systematically coded, and examined using thematic analysis to capture recurring patterns, experiences, and strategic insights. To further assess the practical feasibility of neuromarketing adoption in the Indian agri-food sector, a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) was also conducted.

The study was carried out in compliance with established ethical guidelines. Participants were fully briefed on the objectives of the research and provided informed consent—either written or verbal—prior to their participation. Anonymity and confidentiality were rigorously upheld, and no personal or sensitive information was disclosed. Ethical clearance was obtained from the relevant institutional review board before commencing fieldwork.

While the study generated valuable insights, it also encountered certain limitations. As neuromarketing is still an emerging field in India, the number of firms actively using such tools was limited. This constrained the scope of data collection and the availability of firm-specific case studies. Moreover, access to proprietary neuromarketing data was restricted due to corporate confidentiality policies. Finally, the use of purposive sampling and the exploratory nature of the study limited the generalizability of findings but provided a strong foundation for future research and targeted application.

Additionally, To some extent, AI tools like ChatGPT were utilized solely to enhance grammatical clarity and ensure the manuscript is free of errors.

Results

Table 1. Classification of Invasive and Non Invasive Neuromarketing techniques

Type	Technique	Measures/Description	Usage in Marketing
Invasive	Intracranial EEG (iEEG), DBS	Direct neural activity through implants	Clinical or neuroscience research only
Non-Invasive	EEG	Brain wave patterns, engagement, attention	Widely used in ad testing and product design
Non-Invasive	fMRI	Blood flow in the brain, emotional and cognitive processing	Deep insights; expensive, mostly academic/advanced
Non-Invasive	Eye Tracking	Gaze fixation, visual attention, scan path	Website layout, packaging, in-store navigation
Non-Invasive	Facial Coding	Emotional expression via micro-expressions	Real-time emotional reactions to ads/products
Non-Invasive	Galvanic Skin Response	Emotional arousal, stress/excitement	Emotional impact of stimuli (ads, pricing, messages)
Non-Invasive	Heart Rate Monitoring	Physiological arousal and emotional intensity	Identifying emotional peaks in consumer response
Non-Invasive	Biometric Sensors	Breathing, posture, pupil dilation	Overall emotional and physical response assessment
Non-Invasive	Implicit Association Test (IAT)	Subconscious preferences and biases	Brand perception, hidden attitudes, loyalty insights

Non-Invasive	VR/AR (Virtual/Augmented Reality)	Simulated real-world environments and consumer interactions	In-store simulations, product experience, immersive testing

Table 2. Neuromarketing techniques and their implications in the agri-food sector

Neuromarketing Technique	Key Findings	Strategic Implications
Eye-Tracking Technology	- Consumers fixate on clean, minimalistic packaging with high-contrast elements. - Sustainability labels and health claims attract attention, but complex designs reduce engagement. - Positioning of price, claims, and certifications influences purchase intent.	- Highlight core messages (e.g., "organic", "local") in visually prominent areas. - Avoid cluttered or text-heavy designs to support faster decision-making. - Use contrast and focal design elements to guide consumer gaze effectively.
Facial Expression Analysis (FEA)	- Positive emotions like happiness and trust are linked to products with health and sustainability narratives. - Confusion and skepticism arise from ambiguous or unfamiliar labels. - Seasonal and limited editions evoke excitement.	- Incorporate emotional storytelling to humanize sustainable brands. - Simplify label language and include familiar symbols to build trust. - Launch seasonal or exclusive products to create emotional appeal and urgency.
Electroencephalography (EEG)	- Health benefit claims (e.g., "low sugar") increase cognitive engagement. - Too many product choices cause cognitive overload- Familiar and nostalgic cues evoke stronger neural responses.	- Communicate health benefits clearly and succinctly. - Limit excessive product variations to simplify consumer choices. - Use heritage branding and nostalgic themes to boost brand preference.
Galvanic Skin Response (GSR)	- Novel foods like plant-based alternatives spark excitement. - Traditional foods generate less arousal but deeper loyalty- Promotions elevate arousal, but quality perception outweighs price for premium items.	- Introduce innovative products while retaining familiar elements for consumer comfort. - Balance innovation with tradition to target diverse segments. - Align pricing with quality perceptions for premium products.
Implicit Association Testing (IAT)	- Strong subconscious preference for organic, local, and sustainable foods. - Artificial ingredients trigger negative associations. - Unfamiliar terms like “regenerative agriculture” need explanation.	- Emphasize authentic sustainability claims, supported by credible certifications. - Highlight natural, fresh, and minimally processed product attributes. - Implement educational campaigns to increase

		familiarity with advanced sustainability concepts.
Virtual Reality (VR) & Augmented Reality (AR)	- AR features (e.g., interactive labels) boost engagement and trust. - VR studies show consumers prefer thematic store layouts. - Personalized digital experiences enhance brand recall.	- Use AR to showcase origin stories, certifications, and usage tips. - Apply VR insights to optimize store design and product categorization. - Offer AI-driven personalized recommendations in digital shopping environments.

Source: Formulated by the author from collected survey responses.

Table 3: Summary of Neuromarketing Awareness, Application, and Barriers in India's Agri-Food Sector

Aspect	Findings
Total Respondents (Survey)	120 professionals from marketing firms, agribusinesses, FMCGs, and research institutions
Awareness of Neuromarketing	27% familiar with neuromarketing as a field; 46% aware of individual tools (e.g., eye-tracking, facial coding)
Implementation Rate	Only 14% reported active implementation within their organizations
Primary Users	Food-tech startups and large FMCG firms in metropolitan areas (Delhi-NCR, Mumbai, Bengaluru)
Common Tools Used	Eye-tracking, EEG headsets, facial emotion analysis
Application Areas	Product testing, packaging design, digital ad evaluation
Barriers to Adoption	High costs, lack of trained professionals, limited business awareness, ethical concerns, lack of access among SMEs
Cultural Concerns	Discomfort with biometric monitoring noted by several experts
Interest in Future Use	65% of participants showed interest in applying neuromarketing to enhance understanding of health, sustainability, and food safety preferences
Promising Areas for Adoption	Marketing of organic products, millets, plant-based foods, and sustainability-driven branding strategies

The results of the study revealed a complex but promising landscape for the application of neuromarketing within India's agri-food sector. The Invasive and Non-Invasive Neuromarketing techniques were identified & classified **(Table 1)** and their implications in the agri-food sector were also discussed **(Table 2).** Quantitative data collected from 120 respondents across marketing firms, agribusinesses, FMCG companies, and research institutions indicated that awareness of neuromarketing remained relatively low overall **(Table 3 & Figure 1).** Only 27% of respondents stated that they were familiar with neuromarketing as a formal field of study or practice. However, a larger portion—about 46%—had heard of individual tools such as eye-tracking or facial coding, suggesting fragmented but growing exposure to neuromarketing technologies.

Thematic analysis of 12 expert interviews further revealed that the major barriers to adoption included high costs of neuromarketing equipment, lack of trained professionals, limited awareness about its business value, and ethical ambiguities. Respondents highlighted that small and medium-sized enterprises (SMEs), which are the cornerstone of India's agri-food economy, often lack the technological infrastructure and specialized expertise required to effectively implement neuromarketing techniques. Experts suggest that cultural factors, including consumer discomfort with biometric monitoring, could potentially hinder its wider acceptance.

The results of the study demonstrate a high interest in neuromarketing, notably for improving the customer experience and supporting sustainable consumption. Over 65% of respondents were interested in learning about customer preferences for health, sustainability, and food safety, particularly for marketing efforts promoting organic goods, millets, and plant-based meals. This demonstrates the power of neuromarketing in promoting environmentally conscientious products.

Among those familiar with neuromarketing, only 14% of respondents reported that their organizations had actively implemented such tools in any part of their marketing or product development processes. The use of neuromarketing was found to be more common among food-tech startups and larger FMCG companies operating in metropolitan regions, particularly Delhi-NCR, Mumbai, and Bengaluru. These firms were primarily using eye-tracking, EEG headsets, and facial emotion analysis during product testing, packaging design, and digital advertisement evaluation.

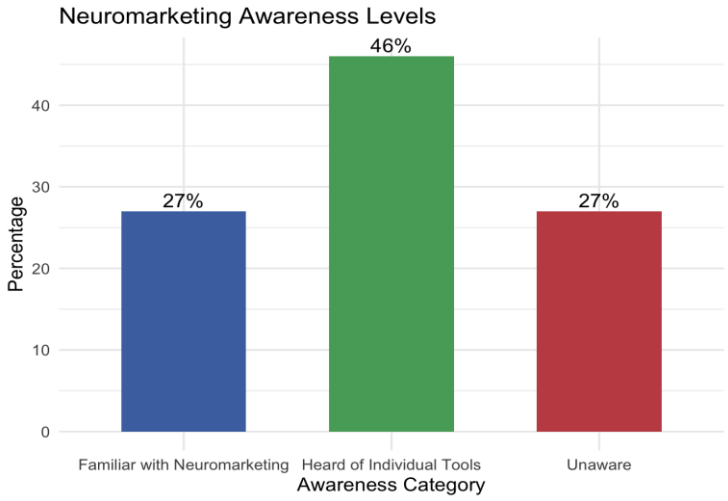

Figure 1. Neuromarketing Awareness level.

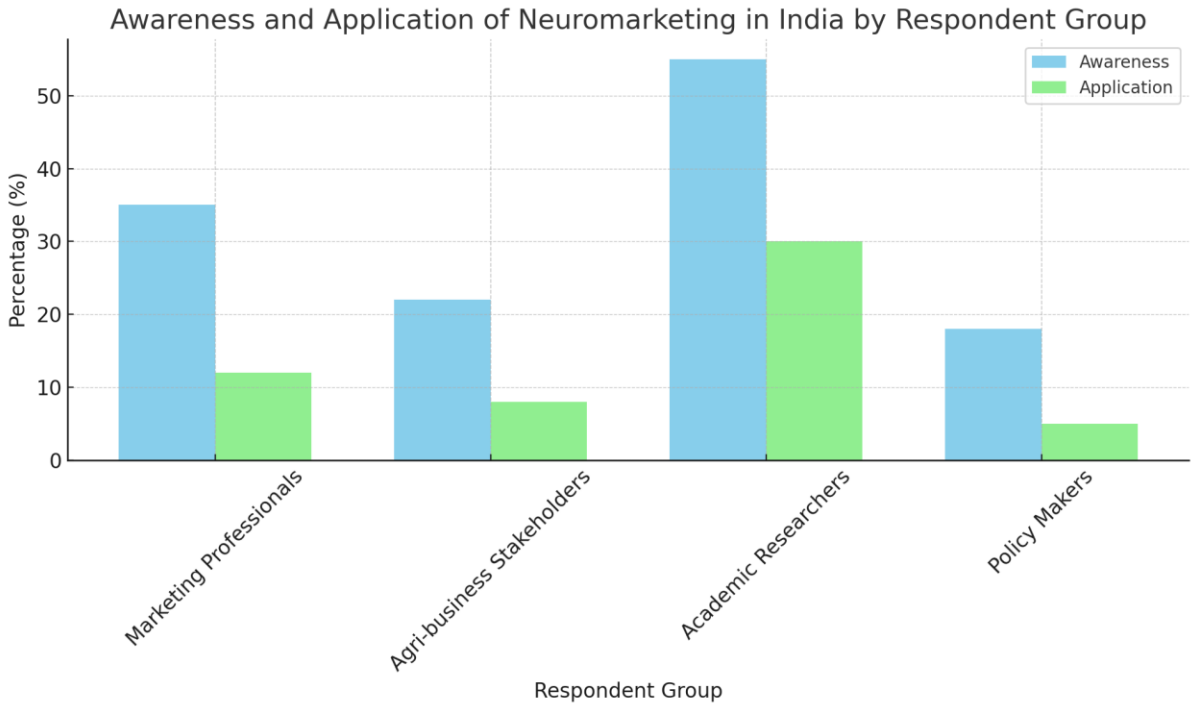

Figure 2. The levels of awareness and application of neuromarketing among various stakeholder groups in India.

The research findings show the levels of awareness and application of neuromarketing among various stakeholder groups in India **(Table 4 & Figure 2)**. The data highlights that academic researchers exhibited the highest awareness (55%), while actual application remained low across all groups, especially among policy makers and agri-business stakeholders.

Table 4: the levels of awareness and application of neuromarketing among various stakeholder groups in India

Stakeholder Group	**Awareness (%)**	**Application (%)**	**Interpretation**
Academic Researchers	55%	18%	Highest awareness, but limited implementation in real-world agri-food studies.
Marketing Professionals	42%	22%	Moderate awareness with slightly higher application due to digital marketing use.
Agri-Business Firms	33%	12%	Awareness and usage both low due to resource constraints and limited exposure.
Startups in Food Sector	47%	27%	Relatively higher interest in applying new tech like neuromarketing.
Policy Makers	15%	5%	Very low awareness and negligible application in public sector initiatives.
Consumers (Survey Sample)	28%	Not Applicable	Low awareness; no direct application but key to understanding consumer response.

The findings indicated a varied level of awareness and application of neuromarketing techniques across different stakeholder groups in India's agri-food sector. Academic researchers showed the highest theoretical understanding, with over 55% acknowledging familiarity with neuromarketing principles. However, only 18% had ever employed these tools in their research. Marketing professionals reported moderate awareness (42%) and the second-highest application rate (22%), typically in digital ad testing and packaging design.

Startups in the food sector demonstrated a relatively higher inclination to experiment with neuromarketing tools, reflecting their adaptive and innovation-driven culture. About 47% had heard of the concept, and nearly 27% had tried applying basic tools like eye-tracking or biometric response measurement for product testing.

In contrast, traditional agri-business firms reported low awareness (33%) and even lower application (12%), mostly constrained by lack of technical know-how and funding. Policy makers, a crucial stakeholder for institutionalizing any innovation, reflected a concerning lack of engagement, with only 15% showing awareness and a mere 5% acknowledging any exposure to neuromarketing frameworks.

The consumer sample, while not directly involved in application, showed minimal familiarity with the term (28%), though they unwittingly served as respondents in neuromarketing studies conducted by private entities.

Table 5: A comparative table showing key metrics across regions

Region Type	**Example Cities**	**Awareness of Neuromarketing**	**Application of Tools**	**Access to Training**	**Key Barriers**
Metropolitan/Tier-1	Bengaluru, Mumbai, Delhi, Hyderabad	High	Moderate to High	Available	Cost, Integration complexity
Tier-2 Cities	Nagpur, Coimbatore, Lucknow	Low	Low	Limited	Awareness, Infrastructure
Rural Areas	Villages in Odisha, Bihar, MP	Very Low	None or Negligible	Absent	Digital divide, Lack of knowledge

The study revealed important nuances in the awareness and application of neuromarketing in India's agri-food sector, highlighting both gaps and opportunities. Regionally, stakeholders from metropolitan and Tier-1 cities such as Bengaluru, Mumbai, Delhi, and Hyderabad exhibited significantly higher awareness and engagement with neuromarketing tools. In contrast, stakeholders from Tier-2 and rural regions reported very limited exposure. This urban–rural digital and knowledge divide suggests that access to neuromarketing is currently an elite, urban phenomenon **(Figure 3 and Table 5).**

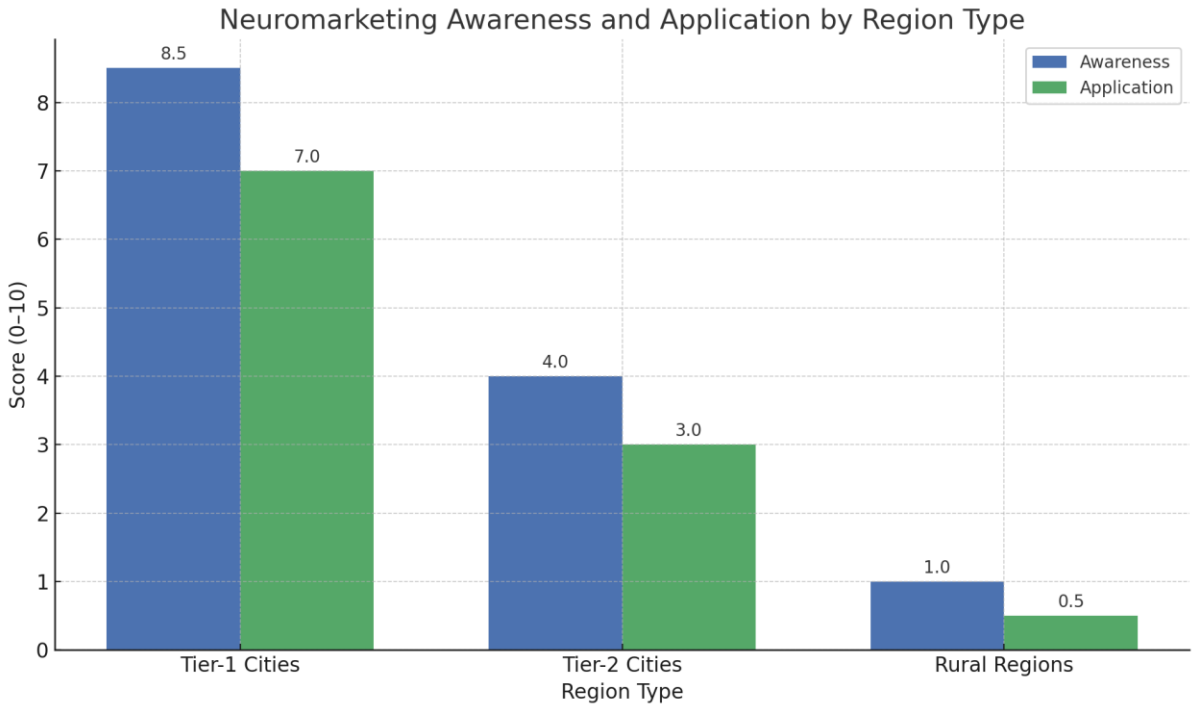

Figure 3. The disparity in neuromarketing awareness and application across different region types in India's agri-food sector.

Table 6: Neuromarketing Awareness and Application by Education & Industry Segment

Category	Sub-group	Awareness Level	Application Level	Key Characteristics
Education Background	Business Administration	High	Moderate to High	Marketing focus; open to consumer insight tools
	Consumer Psychology / Neuroscience	High	High	Familiarity with biometric and behavioral methods
	Agricultural Sciences	Low	Low	Domain-specific focus; limited exposure
	Technical/Engineering	Low to Moderate	Low	Analytical orientation; lack of behavioral insight training
Industry Segment	Startups (Food-tech, Agri-tech)	High	High	Agile, innovation-driven, open to experimentation
	FMCG (Tech-driven)	High	Moderate to High	Consumer-centric, digital-savvy
	Large Agri-business Firms	Moderate	Low	Bureaucratic, traditional approaches, limited innovation budgets
	Agricultural Cooperatives	Low	Very Low	Community-driven, budget and knowledge constraints

In terms of education, individuals with backgrounds in business administration, consumer psychology, and neuroscience showed greater familiarity and openness toward neuromarketing applications. Those with only agricultural or technical education were less likely to be aware of or apply such tools. This reveals a need to integrate neuromarketing concepts into interdisciplinary education programs in agricultural universities and management schools to bridge the awareness gap **(Table 6)**.

Industry segment-wise, startups and tech-driven FMCG firms showed the highest application rates. These organizations are typically more agile, innovation-oriented, and willing to experiment with biometric testing and consumer sentiment analysis. In contrast, large agri-business firms and cooperatives showed lower application levels, possibly due to bureaucratic inertia, traditional marketing reliance, and budget constraints. SDG 4 (Quality Education) through academic integration and industry collaboration applicable here **(Table 6)**.

Table 7: Perception Link Between Sustainability and Neuromarketing

Branding Focus	**% Willing to Adopt Neuromarketing**	**Common Perceived Benefits**
Sustainability-Oriented Firms	68%	Understanding emotional response to green labels, packaging, local foods
Non-Sustainability-Oriented Firms	32%	Less emphasis on subconscious or emotional consumer behavior

Source: Compiled by the author.

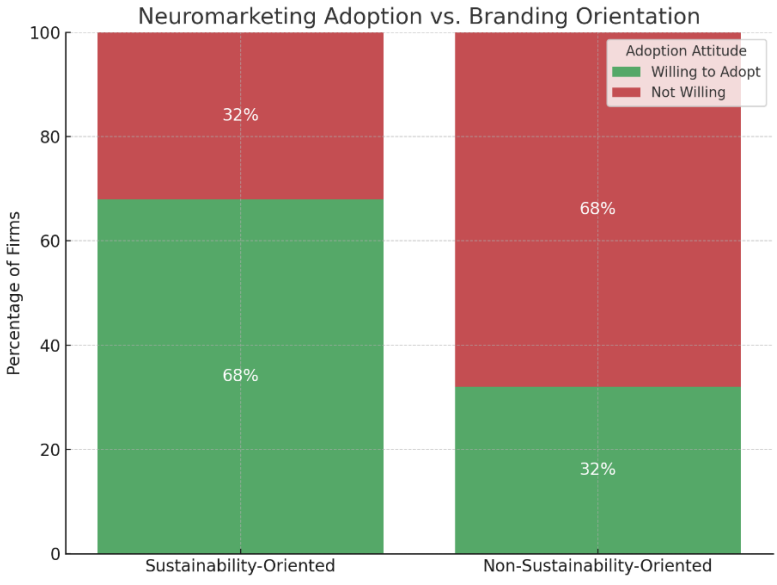

Figure 4. Perception Link Between Sustainability and Neuromarketing

The results also shown in Table 7 and Figure 4, a positive relation between sustainability-oriented branding and willingness to adopt neuromarketing tools. Firms that had previously undertaken environmental or social responsibility campaigns were more likely to recognize the value of understanding consumers' subconscious

attitudes toward eco-labeled products or sustainable packaging. Interview data supported this trend, with several respondents stating that neuromarketing could help decode hidden consumer biases that traditional methods often overlook—such as the emotional impact of "green" packaging, or the appeal of local and seasonal food items.

Table 8: Fuzzy AHP Results for Neuromarketing Adoption in India's Agri-Food Sector

Category	Item	Weight	Interpretation / Strategic Implication
Adoption Criteria	Accuracy	0.301	Top priority; firms seek precise consumer insights to target sustainability messages effectively.
	Biasness	0.235	Minimizing subjective bias is essential for capturing subconscious attitudes toward green consumption.
	Probing Memory & Emotions	0.162	Emotional engagement is key to promoting eco-friendly food products (e.g., millets, organic items).
	Information Quality	0.12	Reliable consumer data is critical for designing persuasive sustainable branding and advertising.
	Time-saving	0.085	Efficiency is valued, though less so than insight quality.
	Usefulness	0.06	General utility is noted but not a primary driver.
	Cost	0.037	Surprisingly low priority; firms are willing to invest if tools provide value for sustainability outcomes.
Application Areas	Advertising	0.61	Main application focus; neuromarketing is seen as crucial for crafting compelling, green-themed campaigns.
	Branding	0.271	Used to emotionally align brands with consumer values (e.g., authenticity, local sourcing).
	Consumer Decision Making	0.073	Indirect influence via campaigns; less directly managed.
	Product Development	0.029	Underutilized; a potential area to explore for sensory and emotional product design.
	Pricing	0.017	Minimal role in current strategy; still dominated by traditional analytics.

The Fuzzy Analytic Hierarchy Process (Fuzzy AHP) was utilized to determine the relative weights of adoption criteria and application alternatives through expert-based pairwise comparisons, using symmetric triangular fuzzy numbers. Aggregated fuzzy judgment matrices were developed from expert inputs, and the consistency of these comparisons was assessed using the approach outlined by Gogus [14], confirming data reliability with acceptable inconsistency ratios.

The final prioritization, presented in **Table 8 and Figure 5**, indicates that accuracy and bias emerged as the most critical criteria influencing the adoption of neuromarketing tools for sustainable product marketing in India's agri-food sector. Among the application areas, advertising (weight = 0.610) and branding (weight = 0.271) were identified as the most impactful, highlighting the domains where business decision-makers are most likely to apply neuromarketing techniques to strengthen consumer engagement and advance sustainability-oriented strategies[15,16].

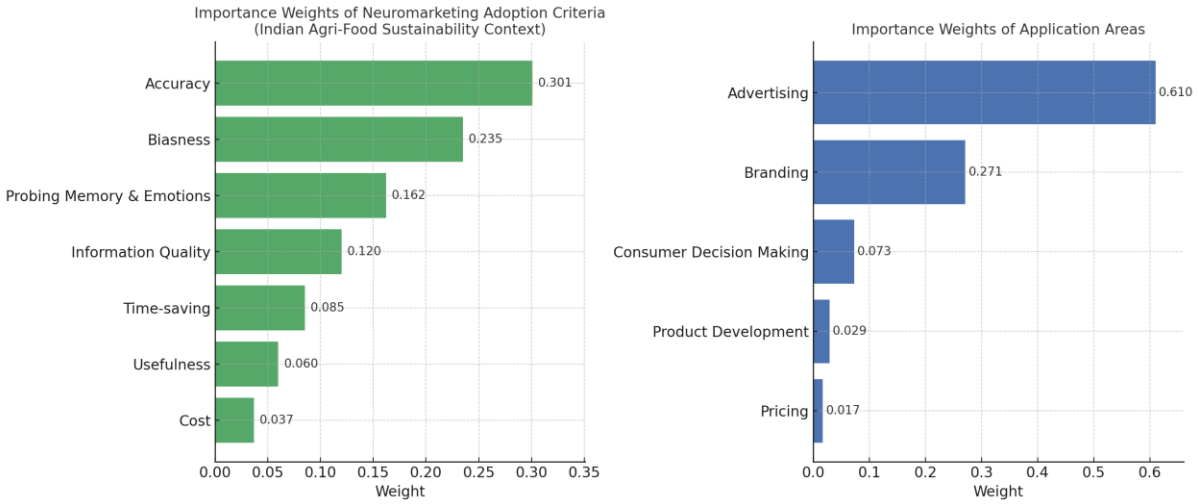

Figure 5. Fuzzy AHP bar charts reflecting the Indian agri-food sustainability context

Left Chart: Importance weights of **adoption criteria** (e.g., Accuracy, Biasness)

Right Chart: Weights of **application areas** (e.g., Advertising, Branding)

Table 9. SWOT Analysis– Neuromarketing in India's Agri-Food Sector

Strengths	**Weaknesses**
- Expanding tech ecosystem - Growing consumer interest in health & sustainability - Presence of global neuromarketing firms Strengths - Expanding tech ecosystem - Growing consumer interest in health & sustainability - Presence of global neuromarketing firms	- High cost of neuromarketing tools - Limited awareness and expertise - Low penetration in rural/Tier-2 sectors Weaknesses - High cost of neuromarketing tools - Limited awareness and expertise - Low penetration in rural/Tier-2 sectors
Opportunities	**Threats**
- Training & capacity-building programs - Academic–industry collaborations - Integration with digital marketing and consumer analytics platforms	- Ethical concerns (e.g., subconscious manipulation) - Data privacy and consent challenges - Regulatory uncertainty on biometric data use

Source: Compiled by the author.

Furthermore, the SWOT analysis **(Table 9)** suggested that while the current penetration of neuromarketing was low, there existed substantial opportunities for growth. Strengths included India's expanding tech ecosystem, increasing consumer awareness of health and sustainability, and the availability of global neuromarketing firms. Weaknesses were primarily related to cost and awareness, while opportunities lay in training programs, collaborations with academic institutions, and integration with digital marketing strategies. Threats included ethical concerns, data privacy issues, and potential misuse of emotional manipulation in advertising.

In summary, the findings demonstrated that while neuromarketing remained an emerging and underutilized tool in the Indian agri-food sector, it held significant potential—especially when aligned with sustainable marketing objectives. The study confirmed that strategic adoption of neuromarketing could help bridge the gap between consumer intentions and behaviors, leading to more effective, ethical, and sustainability-driven marketing practices.

Discussion

From a sustainability perspective, the application of neuromarketing in the agri-food sector can be transformative. Sustainable food consumption often requires nudging consumers toward healthier, locally sourced, and environmentally friendly food products. The techniques can reveal underlying judgements and emotional motives in food buying habits, allowing marketers to create ads that connect with sustainability aims and resonate more powerfully with customers. EEG and eye-tracking tools may be used to improve eco-friendly packaging, organic certification labels, and communication promoting purchase of local millets [16,17].

Neuromarketing can help address systemic issues like food waste and supply chain inefficiency by improving consumer preferences prediction. This allows producers and retailers to make informed decisions about inventory management and targeted marketing, promoting sustainable food purchases and enhancing consumer well-being and environmental sustainability. The paper cites various impediments to mainstream neuromarketing adoption in India, including a lack of technical competence, restricted research infrastructure, expensive biometric technology prices, and ethical issues over consumer privacy. To address these challenges, researchers, industry stakeholders, and governments must work together to strengthen skills [18] and expand access.

The application of this concept is still at early stage in Indian agri-food sector; however, it holds potential for driving sustainable innovations. Raising awareness, building technical capacity, and integrating neuromarketing practices into sustainable development strategies could position India at the forefront of responsible, neuroscience-informed marketing.

Conclusion

Despite worldwide growth, neuromarketing remains mostly limited in the Indian agri-food industry, with urban entrepreneurs dominating. There has been an immense rise in knowledge among academics and marketing professionals, but real application remains limited, notably among agricultural firms and politicians. This discrepancy is due to limited exposure, inadequate research infrastructure, and a lack of multidisciplinary collaboration. This research demonstrates that there is a growing interest in neuromarketing tools, particularly among emerging food entrepreneurs and researchers, as competition in the agri-food industry and consumer demand for health-oriented, environmentally sustainable products increase, which has the potential to significantly transform Indian food businesses' communication and innovation.

Neuromarketing tools can support the promotion of sustainable food products such as millets, organically grown produce, and traditional crops by helping marketers craft emotionally resonant campaigns that align with consumer values and subconscious preferences. For instance, visual stimuli (e.g., eco-labels, earthy colors, traditional motifs) and storytelling (e.g., local farmer narratives, climate resilience) that trigger favorable brain responses can significantly influence buying decisions toward climate-smart and nutritionally rich crops.

This is particularly significant in light of India's observance of 2018 as the National Year of Millets & 2023 as the International year of Millet (IYOM) and its dedication to achieving key United Nations Sustainable Development Goals (SDGs), notably SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production). By applying a neuromarketing framework, stakeholders can enhance consumer receptivity toward traditional and indigenous grains, decrease dependence on water-intensive crops such as rice, and foster the adoption of biodiverse, regenerative agricultural practices.

Limitations of the Study is, while this study contributes novel insights into the intersection of neuromarketing and sustainability in India's agri-food sector, it is not without limitations. First, the sample size, though diverse, may not fully capture the heterogeneity of all stakeholders across India, particularly in rural and marginalized regions. Second, the awareness and adoption levels reported are context-specific and may evolve rapidly with changing market dynamics, limiting the generalizability of findings over time. Third, the use of the Fuzzy AHP model, while robust for prioritization, simplifies complex behavioral and contextual factors that could be further explored using longitudinal or experimental designs. Lastly, neuromarketing applications in sustainability remain an emerging field, and thus the available comparative literature is limited, which may constrain the depth of cross-study validation.

Policy Implications

Capacity Building and Education: There is a need for targeted training programs to build neuromarketing skills among agricultural economists rural marketers and agribusiness professionals. This should include workshops certification courses and academic modules integrated into agricultural universities and management institutes.

Public-Private-Academic Collaborations: Establishing neuromarketing research labs and incubation centers through collaborations between government institutions (like ICAR and NIFTEM) private firms, and universities can accelerate innovation and ensure equitable access to neuro-analytical tools.

Funding and Incentives: Financial incentives such as R&D grants, technology adoption subsidies, or startup seed funds could support early-stage adoption of neuromarketing in food enterprises, particularly those promoting climate-resilient and sustainable food products.

Policy Alignment with Sustainable Food Campaigns: Government-led nutrition awareness campaigns like "Eat Right India" and "Poshan Abhiyaan" should consider integrating neuromarketing insights to design more impactful public messaging strategies.

Ethical Guidelines and Consumer Privacy: As neuromarketing engages with subconscious behavior, it is essential to develop robust ethical frameworks to ensure transparency, data protection, and voluntary participation in neuromarketing studies.

List of Abbreviations:

- Electroencephalography (EEG)
- Fast-Moving Consumer Goods (FMCGs),
- Sustainable Development Goals (SDGs)
- Galvanic Skin Response (GSR)
- Functional Magnetic Resonance Imaging (FMRI)
- Triangular fuzzy numbers (TFN)
- Implicit Association Testing (IAT)
- Facial Expression Analysis (FEA)
- Virtual Reality (VR)
- Augmented Reality (AR)

Author Contributions Conceptualization, Data collection, Methodology, Visualization, Data curation, Software, Formal analysis, and Writing of the original draft: S.R., E.K., B.K.M., P.D.; Manuscript Revision, Resources, Writing – Review & Editing, Visualization, Supervision, Investigation, Validation: P.S.B., V.K., S.K.; Data curation, Software, and helped in formal analysis: D.S.R.

Availability of Data and Materials: All data supporting the findings of this study are included within the manuscript.

Ethical Approval and Consent to Participate:

The study protocol was approved by the Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, 221005, India; on 06 Feb, 2025, no approval number was issued. The authors kindly confirm that all participants provided informed consent prior to participation.

Funding: No external funding was received for this research

Conflicts of Interest: "The author(s) declare no conflicts of interest regarding this manuscript."

Consent for Publication: Not applicable.

Acknowledgments

We gratefully acknowledge the guidance and academic support provided by faculty members of the Department of Agricultural Economics, Banaras Hindu University.

This work also benefitted from interdisciplinary knowledge drawn from neuroscience, marketing, and agribusiness sectors. We appreciate the assistance of research participants, agri-food entrepreneurs, and policy stakeholders who shared their views during the study.

The incorporation of advanced neuromarketing tools, including EEG, IAT, and immersive VR/AR simulations, reflects the integration of cognitive science with sustainable development objectives—offering new pathways for consumer-centric policy and market strategies.

The authors gratefully acknowledge the use of ChatGPT, developed by OpenAI in assisting with language refinement and improving clarity in the preparation of this manuscript. All interpretations, conclusions, and any errors remain the sole responsibility of the authors.

References

1. Sanfey, A. G.; Rilling, J. K.; Aronson, J. A.; Nystrom, L. E.; Cohen, J. D. The Neural Basis of Economic Decision-Making in the Ultimatum Game. *Science* **2003**, *300*, 1755–1758.
2. Young, C. Brain Waves, Picture Sorts®, and Branding Moments. *J. Advert. Res.* **2002**, *42*, 42–53.
3. Reimann, M.; Schilke, O.; Weber, B. Neural Correlates of Trust in Brands: An fMRI Study. *J. Mark. Res.* **2011**, *48* (6), 937–950.
4. Weber, B. Neuroeconomics. In *Consumer Science: Framework Conditions, Fields of Research and Institutions*; Kenning, P., Oehler, A., Reisch, L. A., Grugel, C., Eds.; Springer: Wiesbaden, Germany, 2017; pp. 329–340. (In German)
5. Maria, R., et al. Neuromarketing in the Agri-Food Sector. *Int. Univ. Logist. Transp.* **2022**. https://repository.iuls.ro/xmlui/handle/20.500.12811/3469.
6. McClure, S. M.; Li, J.; Tomlin, D.; Cypert, K. S.; Montague, L. M.; Montague, P. R. Neural Correlates of Behavioral Preference for Culturally Familiar Drinks. *Neuron* **2004**, *44* (2), 379–387.
7. Murphy, E. R. Neuroethics of Neuromarketing. *J. Consum. Behav.* **2008**, *7*, 293–302.
8. Trocchia, P. J. Caving, Role Playing, and Staying Home: Shopper Coping Strategies in a Negotiated Pricing Environment. *Psychol. Mark.* **2004**, *21*, 823–854.
9. Nilashi, M.; Yadegaridehkordi, E.; Samad, S.; Mardani, A.; Ahani, A.; Aljojo, N.; Razali, N. S.; Tajuddin, T. Decision to Adopt Neuromarketing Techniques for Sustainable Product Marketing: A Fuzzy Decision-Making Approach. *Symmetry* **2020**, *12* (2), 305. https://doi.org/10.3390/sym12020305
10. Chen, J.-F.; Hsieh, H.-N.; Do, Q. H. Evaluating Teaching Performance Based on Fuzzy AHP and Comprehensive Evaluation Approach. *Appl. Soft Comput.* **2015**, *28*, 100–108. https://doi.org/10.1016/j.asoc.2014.11.044
11. Yadegaridehkordi, E.; Nizam, M. H. N. B. M.; Noor, N. F. B. M.; Shuib, L.; Badie, N. Predicting the Adoption of Cloud-Based Technology Using Fuzzy Analytic Hierarchy Process and Structural Equation Modelling Approaches. *Appl. Soft Comput.* **2018**, *66*, 77–89. https://doi.org/10.1016/j.asoc.2018.02.029
12. Govindan, K.; Kaliyan, M.; Kannan, D.; Haq, A. N. Barriers Analysis for Green Supply Chain Management Implementation in Indian Industries Using Analytic Hierarchy Process. *Int. J. Prod. Econ.*

2014, *147*, 555–568. https://doi.org/10.1016/j.ijpe.2013.08.018

13. Larimian, T.; Zarabadi, Z. S. S.; Sadeghi, A. Developing a Fuzzy AHP Model to Evaluate Environmental Sustainability from the Perspective of Secured by Design Scheme—A Case Study. *Sustain. Cities Soc.* **2013**, *7*, 25–36. https://doi.org/10.1016/j.scs.2012.03.004
14. Gogus, O.; Boucher, T. O. Strong Transitivity, Rationality and Weak Monotonicity in Fuzzy Pairwise Comparisons. *Fuzzy Sets Syst.* **1998**, *94* (2), 133–144. https://doi.org/10.1016/S0165-0114(96)00110-2.
15. Rathour, S., Badal, P.S., Kamalvanshi, V., Kushwaha, S., Devegowda S.R., Kemboi, E., Mannepalli, B.K., and Deep, P. From Brainwaves to Buying Behavior: Applications of Non-Invasive Neuromarketing Approaches to Food Choice. *Journal of Scientific Research and Reports,* **2025**; 31 (6):195-210. ISSN: 2320-0227 https://doi.org/10.9734/jsrr/2025/v31i63121
16. Bairwa SL, Lakra K, Kushwaha S, Meena LK, Kumar P. Agripreneurship development as a tool to upliftment of agriculture. *International Journal of Scientific and Research Publications.* 2014 Mar;4(3):1-4.
17. Bairwa SL, Kalia A, Meena LK, Lakra K, Kushwaha S. Agribusiness management education: a review on employment opportunities. *International Journal of Scientific and Research Publications.* 2014;4(2):1-4.
18. Kushwaha S, Polycarp IM. Economics of small scale yam production in Qua'an Pau LGA of Plateau. InThe Role of Agriculture in Poverty Alleviation. Proc. 34th Ann. Conf. of Agric. Soc. of Nigeria, held at Abubakar Tafawa Balewa University (ATBU), Bauchi 2001 Oct 15 (pp. 69-74).