

# Chapter 52

## An Analysis of Safety Practices of Farmers in Odisha (India) for Sustainable Agriculture

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### ABSTRACT

*An in-depth review of literature was done in this study which was further followed by consultation and discussion with experts and farmers in the agricultural sectors of Odisha (India) in view of the adoptability perception and behaviours of farmers towards the health and safety practices. Then, a strengths, weaknesses, opportunities, and threats (SWOT) analysis was employed in order to evaluate the current agricultural safety practices by the farmers and its impact for a sustainable agriculture. Further, on the basis of the data and information obtained from the farmers as well as the experts, the major barriers in context with the sustainability indicators (social, environmental, and economic) for the adoption of health and safety practices were obtained followed by the use of the Fuzzy-COPRAS method to rank the barriers in order of their preferences.*

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## **1. INTRODUCTION**

There has been a growing demand for sustainable agriculture in response to the ill-hazards due to agricultural practices. Although, a number of health and safety practices have been developed to protect the farmers from the adverse impacts in agricultural sectors, but because of some constraints as well as barriers, the practices are still found of unused by many of the agricultural workers. One of the major goals of sustainable agricultural systems is decreasing the ill-hazards in agriculture. A good agricultural safety practice is one approach which deals with these issues including the protection of human-health and the environment. Moreover, a number of side effects from the use of synthetic-fertilizers and other agro-chemicals have been found to be utilized in the agricultural sectors in India. Thus, there is a need to address the present issues related to the safety practices in the agricultural sectors. In order to achieve sustainable agriculture, an appropriate consideration to the economic, environmental as well as social factors in the agricultural sectors in India need to be provided and this is achievable through proper and adequate health & safety practices in all aspects of farming. The purpose of this study was to investigate the major barriers to application of good agricultural safety practices in the agricultural sectors of Odisha in India for its sustainability.

A number of studies have been carried-out regarding the uses of personal protective equipments and devices as well as on the ill-hazards with regard to the agricultural sectors. For instance, the agro-chemicals utilization was adopted in order to deal with the issues of deficient food-supplies to meet the ever growing population needs in the nation. A number of side effects have been recorded from the use of synthetic fertilizers as well as other agro-chemicals that usually cause water-pollution as a result of leaching and washing away of such agro-chemicals in rivers by erosions (Smil, 2001). It has been revealed by different studies that by the sustainable agriculture, through various initiatives the present as well as future food-demands can be fulfilled (DFID, 2004; FAO, 2013; Godfray et al., 2010; Oyo and Kalema, 2016). For example, the initiatives were as follows: tillage-reductions (Lal, 1991), crops-rotations (Caporali and Onnis, 1992), managing irrigations (Tilman et al., 2002), integral management of pests (Gurr et al., 2003), nutrients-management, enhancement of wild-habitats, genetic-resistance enhancements, farm-enterprises diversifications, and community-wellbeing improvements (Jackson-Smith, 2010). Geer et al. (2006) have revealed of a higher risk perception of workers owing to a poor-fit & frequency of replacement of personal protective equipment, and cross-contamination by workforce moving into working-zones. In addition to the normal farm level risks, the adolescents may face greater risks by avoiding the use of personal protective equipment or having lack of access to protective machineries. Therefore, the adolescents and their parents should be advised by the health-care providers regarding reduction of risks, and mainly on the personal protective equipment utilizations (Reed et al., 2006). It was suggested to support farmers to invest in physical-safety on the farm and there was a need of evidences of any safety intervention to be a sound health-management as well as economic-investment choice. The farmers were found of neglecting the wear of their hearing protections, due to inconveniences, discomforts as these created new hazards by restricting communication with others (Gates and Jones, 2007; McCullagh and Robertson, 2009). However, Kaustell et al. (2011) have stated that the indications of long-lasting or effectiveness are limited within the literature for such interventions. Organic farming is a multi-functional system that reduces the economic, environmental as well as social functions. Through organic farming the multi-functional benefits include contribution to livelihood improvements, food-security, flexibility to climate-changes, increasing in long run yields, minimizing financial-risks, market-opportunities creation, developing health as well as the environment, hostility to

desertification among other several advantages (IFOAM, 2007). MacFarlane et al. (2008) have reported of 10-40% of farmers usually of not at all using personal protective equipment. Kaustell et al. (2011) have used a collaborative interpretation method and farm interviews for identifying factors affecting the adoption as well as implementation of safety information. The three major barriers were found as personal farmers' characteristics, limited resources for safety-improvements, and slower incremental-evolution of the physical farm-environment with older & hazardous environments remaining along with latest & safer improvements. The agro-based industrial sectors have significant role in the financial system to foster on food-security and basic-needs of human-beings. The occurrence of financial worries and stressed on the farm was associated with the safety assessments made by farmers in Canada (Hagel et al., 2013). Agribusiness has environmental impacts because of land-clearing, leaving-space discontinuities, biological-communities change, soil-disintegration, desertification, eutrophication, and biodiversity-losses (Conway and Barbier, 2013; Fan et al., 2012). The ecosystems get contaminated (Conway and Pretty, 2013; Diaz and Rosenberg, 2008) and human-health gets affected by the use of agrochemicals (WHO, 1996) that include fertilizers and pesticides. Similarly, the agricultural sectors are subjected to adverse environmental-changes with respect to its degree and productivity throughout the world (Battisti and Naylor, 2009; Turrall et al., 2011). Sustainability primarily includes an incorporated and a far reaching way for the well-being to deal with environmental, social, and economic process (Sathaye et al., 2007; Tracey and Anne, 2008) and it requires the support of various stakeholders and point-of-views to build up an advancement through a shared activity-plan (Kates et al., 2005). In order to think about monetary improvement, there was a simultaneous combination of the preservation and rebuilding of the indigenous environment and empowerment in social-values, with the integration of "Environment, Equity and Economy" into a sustainability-model (Daly, 1990). Sustainability in agriculture has a major impact on food-production, and because of persistent use of natural-resources and environmental-effects, it has been a central-concern (Bell and Morse, 2008). The development of sustainable agriculture concern was first focused on the environmental-factors which was further included with social, political and economic factors (DFID, 2003). The economic, social and environmental issues were reported of included in agricultural sustainability (GIZ, 2012; Jackson-Smith, 2010). The capacity of farmers for producing sufficient-foods to feed themselves, their communities, and to maintain the economic-viability of agriculture were included in economic sustainability (Jackson-Smith, 2010; Van Calker, 2008). Social sustainability included the equity along with the quality farmers' life as well as the consumers and members of the community. However, the enhancement of the environment-quality of the landscape and natural-resource bases were included in the environmental sustainability (Sydorovych and Wossink, 2007; Jackson-Smith, 2010). Social, economic and environmental "system of systems (SOS)" was reported to represent the agricultural-systems (Francis et al., 2003). With the improvement & protection of the social, economic and environmental systems of agriculture in a cyclic manner, the agricultural-system can be sustainable. Thus, in order to achieve this, a vigorous system for balancing and to synergize the trade-offs between SOS was suggested to be indispensable (Jackson-Smith, 2010). For resolving the interpretation complexities and to apply agricultural sustainability from local to global levels at different scales with improved consideration of social, economic and ecological flexibilities in agricultural-systems, an efficient and ample evaluation method would be useful. The sustainability assessment was revealed to be relied on human & ecological well-being in order to maintain progress and to increase the integrated sustainability attentions (Astier et al., 2012; Gibson, 2012). Parikhani et al. (2015) have found five barriers to application of "Good-Agricultural-Practices" technologies in livestock units of Meshkinshahr County as the infrastructural, informational-educational, institutional-support, economi-

cal, and personal, respectively. Baksh et al. (2015) have considered 100 small scale commercial vegetable farmers from 10 major-populated agricultural areas across Trinidad, and found an overall good knowledge, fairly positive attitudes of farmers but strong negative perceptions was observed towards the agricultural occupational health & safety issues. By the use of non-renewable resources, most of the inorganic fertilizers as well as chemicals used in agricultures are manufactured such as fossil fuels contributing to pollution and environmental-degradation, and thus results in un-sustainable production in agriculture (Atoma and Atoma, 2015). Parker et al. (2016) have used mental models framework to help in developing an out-reach program for addressing produce-safety in Amish communities in Ohio. The findings of their study expanded the understandings of Amish-growers' perceptions as well as knowledge of on-farm produce-safety practices in the areas like the microbial-risks to fresh & fresh-cut produces, contamination prevention practices, the economic feasibility perceptions of adopting these practices, preparedness for a contamination-event, and information needs with preferences. In a study of farm-workers in Ethiopia, it was found of not receiving any training on chemical-pesticides for 85% of the workers, and only 10% of workers were found of using personal protective equipments with a poor attitude as well as practice in chemical-pesticides handling (Negatu et al., 2016). The gender, safety-training as well as work-regulations were reported to affect the knowledge-levels of the participants regarding the safety issues (Aluko et al., 2016; Tetemke et al., 2014). Gaviglio et al. (2017) have considered the 'South-Milan Agricultural-Park' in Italy, and developed an assessment framework for farm-sustainability based on three aspects: (i) data-collection through interviews with farmers as well as institutions, (ii) elaborating data through aggregative structures, and (iii) scores-analysis. Zeeshan et al. (2017) have assessed the level of knowledge as well as practices of food safety handling among university students and explored the association between knowledge/practices and the academic as well as socio-demographic characteristics. The random and un-safe use of pesticides in agriculture creates major hazards to the environment as well as human health. Gesesew et al. (2017) have assessed the knowledge, attitudes as well as experiences of exposure to pesticides, and related health-problems among farmers using irrigation in Jimma-Zone (Southwest Ethiopia). Further, Jallow et al. (2017) have considered the Kuwaiti farmers about the safer uses of pesticides. Agricultural capabilities include feeding its population, serving as a revenue source to the nation, providing employments as well as employment opportunities, and serving as raw-materials source to agro-related business. At present these functions may not be met because of the rapid growth in population affecting the food production rate and thus reducing to sell overseas (Oluwaseyi, 2017). Apart from discomforts, the personal protective equipment brings in additional physiological burdens to the users by augmentation in heat stresses, heart rates and core temperatures considerably (Coca et al., 2017). Öztas et al. (2018) have evaluated the farmers' knowledge levels in the Çukurova region regarding the pesticides effects, toxic-symptoms, & protective-equipment, and by assessing the attitudes and practices of the farmers about pesticides, an inadequate level of knowledge of farmers about safer use of pesticides was found. Scheinberg et al. (2018) have suggested for a customized food-safety training-program that would greatly benefit the farmers' market vendors for selling safer foods in Pennsylvania, by addressing the recognized issues in addition to the regulatory requirements. The inter-dependencies between different dimensions for farms-sustainability were assessed by Sulewski et al. (2018), which was carried out by considering 601 farms' participation in the "Polish-Farm Accountancy-Data Network". This was supported by supplementary information from interviews, and on a number of variables, including economical, social, environmental, and composite indices for sustainability-measures. Guma et al. (2018) have found a decrease in croplands with the increase in population, as energy, foods and spaces have been a prime requirement for the growing

population. In a study with the consideration of 425 respondents from public-sector organizations in Pakistan, Irfan et al. (2018) have used a survey-based method and “partial least squares structural equation modelling (PLSSEM)” and found a positive relationship between social, environmental, as well as economic sustainability indices and the corporate-reputation. Inaccessibility of pertinent as well as quantifiable indicators depresses the specialists in sustainability-performance assessments. General as well as overall indicators for sustainability should be utilized for specific industrial-sectors (Hsu et al., 2017; Hegab et al., 2018). An integrated sustainability-assessment method has been demonstrated by Ahmad et al. (2019) with the use of the “Monte Carlo Simulation” and “fuzzy logic” approaches in a case study of a “Malaysian food-manufacturing company”. It was found for the company to improve its sustainability-performance more effectively by decreasing the amount of polluted waste-water, air-emissions, etc., and through improvement in the working-conditions. Rostami et al. (2019) have proposed of educational sets consisting of contact with poisons as well as their applications, storages, pesticides carrying, effectiveness of different methods in individual protection facilities, and utilization of the behaviour for reduction of the poisons exposures to be developed and to be made available to the farmers in Kabudrahang County, Iran. Asgedom et al. (2019) have used structured questionnaires in two particleboard factories in Ethiopia, and found a higher proportion of positive-response of the permanent workers on knowledge and attitude towards chemical hazards than the temporary workers. However, very few temporary workers were provided with personal protective equipment as compared to the permanent workers. Mahajan and Patil (2019) have tried to identify strengths, weaknesses, opportunities, and threats for agro-based industrial sectors in India. Zelinka and Amadei (2019) have proposed a methodology by the use of system-dynamics to model the “time-dependent progress” of each one of the 17 “Sustainable Development Goals (SDGs)”, as well as their mutual-interactions. Bahşi and Kendi (2019) have investigated the farmers’ knowledge levels operating agricultural activities of Osmaniye and Konya regions in Turkey. It was observed of having no ideas about occupational health and safety of 45.9% farmers, while only 24.3% of having education about occupational health and safety. Moreover, statistical significant differences were found in age of farmers and learning status, occupational health and safety views of farmers, and their occupational health & safety knowledge requirements in agriculture. It was suggested to establish more awareness on occupational health and safety in the agricultural sectors. Kizito and Semwanga (2020) have demonstrated the need for a shared-system wide-responsibility for road-safety at all levels by modeling the occurrences of road-accidents in Uganda by the use of “dynamic-synthesis methodology (DSM)”. In this study, focus was given on road-accidents prevention by considering the linear as well as non-linear interactions of the variables during the pre-crash phases. Therefore, an attempt was made in this study to investigate the major barriers to the adoption of good safety practices in the agricultural sectors of Odisha in India for its sustainability.

Further, the “strengths, weaknesses, opportunities and threats (SWOT)” analysis has been widely preferred and used in agricultural evaluations. For instance, Humphrey (2005) has used SWOT analysis for evaluating the organic agriculture based on the current agricultural production set-ups as well as progress policies in Bhutan. Kumar and Nain (2013) have made a SWOT analysis of Indian agricultures. The strength was found to lie in having the largest cultivable-lands with food grains production evidences, while weakness was found to lie in having lower yields, not as much of value additions and food-processing and larger quantity of losses in post-harvest. On the basis of primary as well as secondary information from farmers that were obtained by the team members of “Krishi Vigyan Kendra”, the SWOT analysis was carried out by considering the existing farming system in rural areas at Amreli district, Junagadh (Gujarat state in India). The identified strategies playing a vital role in farming system development and

in growing of food security in those areas were: “growth of local market-opportunities and in storage-infrastructures”, “plantation of crops with higher economic-values”, “growth of governmental-supports”, “preparation of strategic-plans for development in organic-farming”, “taking into account of the quality of crops”, “taking into consideration the farm sustainability-indexes”, “use of sustainable water resources-management”, and “developing extension-programs based on needs of farmers”, respectively (Deshmukh et al., 2014). Similarly, Tashi and Wangchuk (2016) have used SWOT analysis to investigate the organic agriculture prospects in Bhutan based on the experts’ point of views.

Moreover, a number of studies have used the “Multi-Criteria Decision-Making (MCDM)” methods that include several techniques for supporting decisions which involves conflicting criterion, disproportionate variables, and a number of possible alternatives or solutions (Doumpos and Zopounidis, 2014; Pohekar and Ramachandran, 2004; Shukla et al., 2019). In order to evaluate the barriers for developing landfill communities, the “interpretive structural modelling-ISM” methodology was used in a study (Chandramowli et al., 2011). Pradhan (2017) has proposed dynamic-heuristics pattern for risk-optimization on “Real Time Operating System (RTOS)” based on available technologies, businesses & resources for anti-fragile technologies. However, the “COmplex PROportional ASsessment (COPRAS)” method has been widely used when the optimal alternative need to be selected by decision-makers among a pool of alternatives in view of a set of evaluation criteria. In case of classical COPRAS method for the evaluation process, the weights of criterion along with the ratings of alternatives are precisely known and the crisp values are employed. Because of the in capabilities of the crisp data in modelling real-life decision problems under several conditions, it becomes difficult for the evaluators for precise ratings of alternatives as well as to assign exact weights to the evaluation criterion. Thus, the benefit of using a fuzzy-approach is to find out the relative importance of attributes by the use of fuzzy numbers rather than the numbers precisely. Parezanović et al. (2016) have demonstrated the “Fuzzy-COPRAS” approach in order to make decisions on mobility measures by evaluating twenty six measures. Bekar et al. (2016) have used the “COPRAS of alternatives with Grey relations (COPRAS-G)” and the “Fuzzy-COPRAS” method for evaluating the performance measures in “total productive maintenance (TPM)” strategy. Zarbakhshnia et al. (2018) have used fuzzy-COPRAS method for ranking and selecting the “sustainable third-party reverse logistics providers” in the existence of risk factors. Therefore, on the basis of the positive outcomes of the MCDM method, the “Fuzzy-COPRAS” method was used in the present analysis for ranking of the barriers in the execution of agricultural safety practices in India.

## **2. RESEARCH METHODOLOGY**

### **2.1 Review of Literature and Discussion With Experts and Farmers**

An in depth review of literature was done which was further followed by consultation and discussion with five experts in the agricultural fields and discussion with the farmers in the agricultural sectors of Odisha (India). The interaction and discussion with farmers was primarily focused on their knowledge levels, availabilities, and safety practices followed in carrying out the agricultural activities on a regular basis.

## 2.2 Analysis of “Strengths, Weaknesses, Opportunities, and Threats (SWOT)”

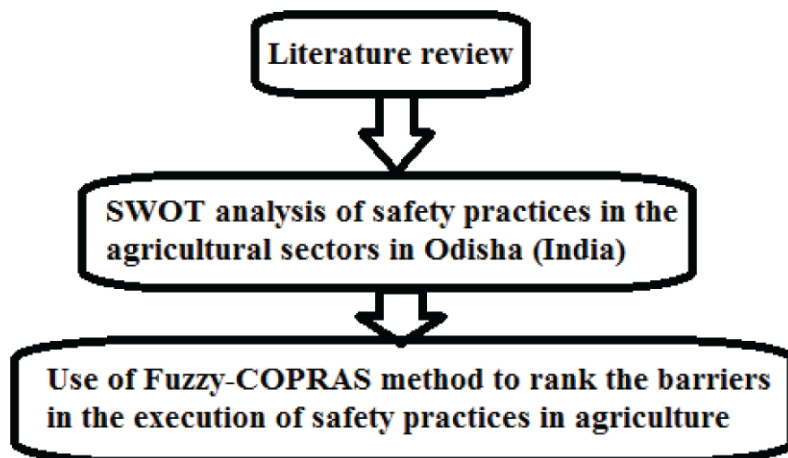
A SWOT analysis was employed in order to evaluate the strengths, weaknesses, opportunities, and the threats based on the current agriculture safety practices by the farmers for a sustainable agriculture.

## 2.3 Analysis of Information and Data

On the basis of the data and information obtained from the farmers as well as the experts, the major barriers in context with the sustainability indicators (social, environmental and economic) for the adoption of health and safety practices among farmers of Odisha were obtained. Then, the fuzzy-COPRAS method was used to rank these barriers in order of their preferences.

The steps followed in this analysis were as shown in Figure 1.

*Figure 1. Steps followed in this analysis*



### 2.3.1 Steps in “Fuzzy-COPRAS” Method

In order to deal with the deficiency in the COPRAS method, the Fuzzy-COPRAS method was used in this analysis. The Fuzzy-COPRAS assigned the criteria weights, and the linguistic terms represented by fuzzy numbers were used for evaluating the ratings of alternatives. The steps involved in the Fuzzy-COPRAS method included the following:

**Step I:** Defining the linguistic terms.

**Step II:** Construction of the fuzzy decision matrix.

**Step III:** Determination of the weights of criteria.

**Step IV:** Determination of aggregate fuzzy-rating  $\hat{x}_{ij}$  of alternative  $A_i$ ,  $i = 1, 2, \dots, m$  under criterion  $C_j$ ,  $j = 1, 2, \dots, n$ :

$C_1, C_2, \dots, C_n$

$$\hat{D} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_M \end{matrix} \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \vdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \vdots & \tilde{x}_{mn} \end{bmatrix}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (1)$$

$$\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3})$$

$$x_{ij1} = \min x_{ijk1}, x_{ij2} = \frac{1}{k} \sum_{k=1}^k x_{ijk2}, x_{ij3} = \min x_{ijk3} \quad (2)$$

where,  $\hat{x}_{ijk}$  is the rating of alternative  $A_i$  with respect to criterion  $C_j$  evaluated by  $k^{\text{th}}$  expert (here  $k = 8$ ),  $\tilde{x}_{ij k} = (\tilde{x}_{ij k1}, \tilde{x}_{ij k2}, \tilde{x}_{ij k3})$ .

**Step V:** Defuzzifying the aggregated fuzzy decision matrix obtained and deriving their crisp values. In this analysis for transforming the fuzzy weights into the crisps weights applied the centre of area method for the calculation of the “best non-fuzzy performance (BPN)” value of the fuzzy weight of each dimensions. The BPN values of the fuzzy number  $\tilde{x}_{ij}$  can be found using the following equation (3):

$$\tilde{x}_{ij} = \tilde{x}_{ij} \cdot \tilde{x}_{ij} = \frac{\left[ (U\tilde{x}_{ij} - L\tilde{x}_{ij}) + (M\tilde{x}_{ij} - L\tilde{x}_{ij}) \right]}{3} + L\tilde{x}_{ij} \quad (3)$$

**Step VI:** Normalizing the decision matrix ( $f_{ij}$ ). The normalization of the decision making is calculated by dividing each entry by the largest entry in each column to eliminate anomalies with different measurement units, so that all the criteria become dimensionless.

**Step VII:** Calculating the weighted normalized decision matrix ( $\hat{x}_{ij}$ ) The fuzzy-weighted normalized values are calculated by multiplying the weight of evaluation indicator ( $w_j$ ) with normalized decision matrices:

$$\hat{x}_{ij} = f_{ij} \cdot w_j \quad (4)$$

**Step VIII:** Sums of attributed values ( $P_i$ ) with larger values more preferably (optimization direction is maximization) calculated for each alternative (line of the decision-making matrix):

$$P_i = \sum_{j=1}^k \hat{x}_{ij} \quad (5)$$

**Step IX:** Sums of attributed values ( $R_i$ ) with smaller values more preferably (optimization direction is minimization) calculated for each alternative (line of the decision-making matrix):



$$R_i = \sum_{j=k+1}^m \hat{x}_{ij} \quad (6)$$

where, (m-k) is number of attributes which must be minimized.

**Step X:** Determining the minimal value of ( $R_i$ ):

$$R_{\min} = \max_i R_i; i = 1, \dots, n \quad (7)$$

**Step XI:** Calculating the relative weight of each alternative ( $Q_i$ ):

$$Q_i = P_i + \frac{R_{\min} \sum_{i=1}^n R_i}{R_i \sum_{i=1}^n \frac{R_{\min}}{R_i}} \quad (8)$$

Formula (8) can to be written as:

$$Q_i = P_i + \frac{\sum_{i=1}^n R_i}{R_i \sum_{i=1}^n \frac{1}{R_i}} \quad (9)$$

**Step XII:** Determining the optimality criterion k:

$$K = \max_i Q_i; i = \overline{1, n} \quad (10)$$

**Step XIII:** Assigning the priority of the alternatives. The greater the weight (relative weight of alternative)  $Q_i$ , the higher is the priority (rank) of the alternatives. The satisfaction degree is high in case of  $Q_{\max}$ .

Then, the utility degree of each alternative was calculated as:

$$N_i = \frac{Q_i}{Q_{\max}} \times 100 \quad (11)$$

where,  $Q_i$  and  $Q_{\max}$  are the weights obtained from equation (8).

### 3. RESULTS AND DISCUSSION

The SWOT analysis of safety practices among farmers in Odisha in context with its sustainability in agriculture in view of the sustainability criteria such as social, environmental and economic aspects was as illustrated in Table 1.

**An Analysis of Safety Practices of Farmers in Odisha (India) for Sustainable Agriculture**

*Table 1. SWOT analysis of safety practices among farmers in Odisha and its sustainability in agriculture*

Strength	Leading to sustainable agriculture with respect to health and environment.	Weakness	Lack of awareness among farmers.
	Reduced risk to farmers.		Lack of adoptability perception among farmers.
	Reduced risk of exposing to harmful chemicals and pesticides.		
Opportunity	Promoting a healthier lifestyle.	Threats	Unsure about the outcome of safety practices.
	A huge export market at regional level.		Lack of availability in local markets.
	A huge export market at international level		

The major barriers as alternatives in context with the sustainability indicators as criterion for the adoption of health and safety practices among farmers of Odisha in India were summarized in Table 2. The identified four barriers concerned to the “Social” indicators were: “Lack of assistance from government, non-government and industry bodies with regard to health and safety practices”, “Lack of proper training and programs about safety practices”, “Discomfort in use of safety devices and practices”, and “More time in the implementation of safety practices”. The three barriers concerned to the “Environmental” indicators were “Lack of access to information about safety practices”, “Non-availability of protective appliances for a regular use, and “Hassle to the source and in the implementation of safety practices”. Similarly, the three barrier obtained as the “Economic” indicator for sustainability were: More cost to implement changes for improved safety practices”, “Inadequate finance for health surveillance programs”, and “Lack of initiatives for subsidized appliances through government”, respectively.

*Table 2. Major barriers in context with the sustainability for the adoption of health and safety practices*

Sustainability Indicators	Barriers
Social (C <sub>1</sub> )	Lack of assistance from government, non-government and industry bodies with regard to health and safety practices (B <sub>1</sub> )
	Lack of proper training and programs about safety practices (B <sub>2</sub> )
	Discomfort in use of safety devices and practices (B <sub>3</sub> )
	More time in the implementation of safety practices (B <sub>4</sub> )
Environmental (C <sub>2</sub> )	Lack of access to information about safety practices (B <sub>5</sub> )
	Non-availability of protective appliances for a regular use (B <sub>6</sub> )
	Hassle to the source and in the implementation of safety practices (B <sub>7</sub> )
Economic (C <sub>3</sub> )	More cost to implement changes for improved safety practices (B <sub>8</sub> )
	Inadequate finance for health surveillance programs (B <sub>9</sub> )
	Lack of initiatives for subsidized appliances through government (B <sub>10</sub> )

### 3.1 Output of “Fuzzy-COPRAS” Method

The criteria along with its types and corresponding weights were as illustrated in Table 3.

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*Table 3. Different criteria weights*

Name of Criteria	Type of Criteria	Weights ( $W_R$ )
Social ( $C_{R1}$ )	Minimization	0.77
		0.83
		0.98
Environmental ( $C_{R2}$ )	Minimization	0.65
		0.78
		0.88
Economic ( $C_{R3}$ )	Minimization	0.77
		0.95
		0.1

The initial integrated-matrix comprising of the weights of all the criterion and corresponding fuzzy numbers of each alternatives with respect to the criteria were as shown in Table 4. Subsequently, the sum of squares and square-root (SQRT) values were obtained as illustrated in Table 5.

*Table 4. Initial integrated-matrix*

	$W_{CR1}$			$W_{CR2}$			$W_{CR3}$		
	0.77	0.83	0.98	0.65	0.78	0.88	0.77	0.95	1
	$C_{R1}$			$C_{R2}$			$C_{R3}$		
$B_1$	14.80	20.20	24.60	5.800	11.00	16.80	2.800	6.400	12.00
$B_2$	3.800	8.200	13.80	10.80	16.60	22.20	13.40	19.40	24.40
$B_3$	7.400	13.00	18.80	8.800	14.60	20.00	7.800	13.40	19.20
$B_4$	3.000	6.800	12.40	19.00	24.40	28.00	14.20	20.20	25.20
$B_5$	13.80	19.80	24.60	6.800	12.20	18.20	3.600	8.000	14.20
$B_6$	8.600	14.00	19.60	8.600	14.00	19.60	12.60	18.60	24.00
$B_7$	16.60	22.20	26.40	6.600	11.20	16.40	3.600	8.200	13.80
$B_8$	6.000	11.20	17.00	6.800	12.20	18.20	7.600	13.00	18.80
$B_9$	14.80	20.20	24.60	11.80	17.80	23.40	13.80	19.80	24.80
$B_{10}$	15.40	21.00	25.40	5.400	10.60	16.60	4.000	7.600	13.00

*Table 5. Sum of squares and “SQRT” values*

<b>Sum of Squares</b>	1329.4	2745.8	4528.4	967.12	2253.4	4097.8	898.76	2100.9	3848.6
<b>SQRT</b>	92.756			85.547			82.754		

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The normalized-matrix and the weighted normalized-matrix were as shown in Table 6 and Table 7, respectively.

*Table 6. Normalized-matrix*

	$W_{CR1}$			$W_{CR2}$			$W_{CR3}$		
	0.77	0.83	0.98	0.65	0.78	0.88	0.77	0.95	1
	$C_{R1}$			$C_{R2}$			$C_{R3}$		
$B_1$	0.1596	0.2178	0.2652	0.0678	0.1286	0.1964	0.0338	0.0773	0.1450
$B_2$	0.0410	0.0884	0.1488	0.1262	0.1940	0.2595	0.1619	0.2344	0.2948
$B_3$	0.0798	0.1402	0.2027	0.1029	0.1707	0.2338	0.0943	0.1619	0.2320
$B_4$	0.0323	0.0733	0.1337	0.2221	0.2852	0.3273	0.1716	0.2441	0.3045
$B_5$	0.1488	0.2135	0.2652	0.0795	0.1426	0.2127	0.0435	0.0967	0.1716
$B_6$	0.0927	0.1509	0.2113	0.1005	0.1637	0.2291	0.1523	0.2248	0.2900
$B_7$	0.1790	0.2393	0.2846	0.0772	0.1309	0.1917	0.0435	0.0991	0.1668
$B_8$	0.0647	0.1207	0.1833	0.0795	0.1426	0.2127	0.0918	0.1571	0.2272
$B_9$	0.1596	0.2178	0.2652	0.1379	0.2081	0.2735	0.1668	0.2393	0.2997
$B_{10}$	0.1660	0.2264	0.2738	0.0631	0.1239	0.1940	0.0483	0.0918	0.1571

*Table 7. Weighted normalized-matrix*

	$C_{R1}$			$C_{R2}$			$C_{R3}$		
$B_1$	0.1229	0.1808	0.2599	0.0441	0.1003	0.1728	0.0261	0.0735	0.1450
$B_2$	0.0315	0.0734	0.1458	0.0821	0.1514	0.2284	0.1247	0.2227	0.2948
$B_3$	0.0614	0.1163	0.1986	0.0669	0.1331	0.2057	0.0726	0.1538	0.2320
$B_4$	0.0249	0.0608	0.1310	0.1444	0.2225	0.2880	0.1321	0.2319	0.3045
$B_5$	0.1146	0.1772	0.2599	0.0517	0.1112	0.1872	0.0335	0.0918	0.1716
$B_6$	0.0714	0.1253	0.2071	0.0653	0.1276	0.2016	0.1172	0.2135	0.2900
$B_7$	0.1378	0.1987	0.2789	0.0501	0.1021	0.1687	0.0335	0.0941	0.1668
$B_8$	0.0498	0.1002	0.1796	0.0517	0.1112	0.1872	0.0707	0.1492	0.2272
$B_9$	0.1229	0.1808	0.2599	0.0897	0.1623	0.2407	0.1284	0.2273	0.2997
$B_{10}$	0.1278	0.1879	0.2684	0.0410	0.0966	0.1708	0.0372	0.0872	0.1571

The ranking of alternatives were based on the higher values of  $N_i$  as summarized in Table 8, and it was observed that the most significant barriers in context with the sustainability for the adoption of health and safety practices in Odisha such as “More cost to implement changes for improved safety practices ( $B_8$ )” ranked first followed by “Lack of assistance from government, non-government and industry bodies with regard to health and safety practices ( $B_1$ )”, “Lack of access to information about safety practices ( $B_5$ )”, “Discomfort in use of safety devices and practices ( $B_3$ )”, “Lack of initiatives for subsidized appliances through government ( $B_{10}$ )”, “Hassle to the source and in the implementation of safety practices

(B<sub>7</sub>)”, “Lack of proper training and programs about safety practices (B<sub>2</sub>)”, “Non-availability of protective appliances for a regular use (B<sub>6</sub>)”, “More time in the implementation of safety practices (B<sub>4</sub>)”, and “Inadequate finance for health surveillance programs (B<sub>9</sub>)”, respectively.

*Table 8. Ranking of alternatives*

Alternatives	P <sub>j</sub>			R <sub>j</sub>			Q <sub>j</sub>			Non-Fuzzy Q <sub>j</sub>	N <sub>j</sub>	Ranking
B <sub>1</sub>	0	0	0	0.193	0.354	0.577	0.030	0.501	6.549	2.360	90.06	<b>2</b>
B <sub>2</sub>	0	0	0	0.238	0.447	0.669	0.026	0.397	5.304	1.909	72.85	<b>7</b>
B <sub>3</sub>	0	0	0	0.200	0.403	0.636	0.027	0.441	6.292	2.253	85.98	<b>4</b>
B <sub>4</sub>	0	0	0	0.301	0.515	0.723	0.024	0.345	4.194	1.521	58.03	<b>9</b>
B <sub>5</sub>	0	0	0	0.199	0.380	0.618	0.028	0.467	6.328	2.275	86.79	<b>3</b>
B <sub>6</sub>	0	0	0	0.254	0.466	0.698	0.025	0.381	4.977	1.794	68.46	<b>8</b>
B <sub>7</sub>	0	0	0	0.221	0.394	0.614	0.028	0.450	5.708	2.062	78.68	<b>6</b>
B <sub>8</sub>	0	0	0	0.172	0.360	0.594	0.02	0.493	7.340	2.621	100	<b>1</b>
B <sub>9</sub>	0	0	0	0.340	0.570	0.800	0.022	0.312	3.707	1.347	51.39	<b>10</b>
B <sub>10</sub>	0	0	0	0.206	0.371	0.596	0.029	0.478	6.133	2.213	84.45	<b>5</b>

#### **4. CONCLUSION**

Agriculture is the primary source of food and livelihood in most of the developing countries. Thus, there is a higher requirement of sustainable agricultural systems fulfilling the sustainability criteria such as economic, social as well as environmental aspects of safe and healthy agriculture in terms of accessibility or availability, utilizations and stability in the farming sectors. This study revealed that the most significant barriers that require appropriate attentions of the competent-authorities in context with the sustainability for the adoption of health and safety practices in the agricultural sectors of Odisha as: “More cost to implement changes for improved safety practices” ranking at first level, which was followed by subsequent descending ranking of “Lack of assistance from government, non-government and industry bodies with regard to health and safety practices”, “Lack of access to information about safety practices”, “Discomfort in use of safety devices and practices”, “Lack of initiatives for subsidized appliances through government”, “Hassle to the source and in the implementation of safety practices”, “Lack of proper training and programs about safety practices”, “Non-availability of protective appliances for a regular use”, “More time in the implementation of safety practices”, and “Inadequate finance for health surveillance programs”, respectively.

The findings of this study will help in formulating appropriate policies in the agricultural sectors for the benefits as well as protection of farmers in view of the ill-hazards in agriculture. Moreover, a clear information and explanation about new technology and safety practices more usable to farmers reduces negative attitude towards the effective and efficient adoption. There is a higher requirement in the role of agricultural extension agents that can affect farmers’ perceptions as well as behaviors to adopt the agricultural health and safety practices in order to achieve sustainability in agriculture throughout the world.

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