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The Meagerness of Simple Likert Scale in Assessing Risk: How Appropriate the Fuzzy Likert is?

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Abstract:

Social scientists around the world commonly use the Likert scale. The scale has some limitations; in many cases, researchers are ignoring those limitations. Many social scientists have been trying to find out an alternative, but all initiatives do not correctly solve the problems. Among all limitations, the most critical issue is that Likert scale adopts a similar variance between two successive scale points. Fuzzy-Likert scale is a useful alternative for solving the existing limitation of the traditional Likert scale. Therefore, the current article describes the limitations of existing Likert scale and application of Fuzzy-Likert scale in perceived risk assessment. Naturally, risks are interrelated with different factors. Assessing risks with simple existing Likert scale is not entirely appropriate. A well-structured Fuzzy-Likert scale can be used to mitigate the existing problems. This article clarifies how efficiently researchers can use a Fuzzy-Likert scale for assessing the perceived risk in agriculture using a simple structured questionnaire with the help of an example. To reach the conclusions and recommendations, the researchers used different published articles, online repositories, report etc. through content analysis.

Keywords: Fuzzy-Likert Scale, Perceived Risk, Social Research, Structured Questionnaire.

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1. RISK AND ITS ASSESSMENT NEXUS IN LIKERT SCALE APPLICATION

Eminent economist Joshef Stiglitz explained Risk as ‘love’ because we all know about risk, but we cannot describe it [Nguyen (2007)]. The probability of loss is the risk, and it depends on vulnerability, exposure, and hazard [(Crichton (1999); Pervez, *et al.* (2019)]. A particular risky event can be categorized by the degree of occurrence, nature of spread frequency, duration, and the previous history. Soussan and Arriens, (2004); Kirilenko *et al*., (2004) and Pervez (2018) explained risk with the following mathematical equation:

$$R = f\,(H \times V) \qquad \ldots (1)$$

where, R= risk, H= hazards and V= vulnerability

Risk can be defined as the probability of an event with its significance to an unfavourable environment [Renn (2008)]. Therefore, risk can be measured by the following equation:

$$\text{Risk} = \text{Probability of an unfavourable event} \times \text{Significance} \qquad \ldots (2)$$

Researchers around the world mostly use Likert scale in survey research. Renis Likert introduced this novel scale in 1932 [Li (2013)], a sociologist at the University of Michigan from 1946 to 1970 [Uebersax (2006)]. While using this scale, a researcher asks respondents to indicate the level of agreements on a particular issue. Fixed choice of responses format is set by the researcher and the attitude towards a specific subject is measured [Bowling (1997); Burns and Grove (1997) in a certain level of agreements or disagreements. For example, a five-points scale has points such as, disagree= 0, agree= 1 strongly agree= 2. The Likert scale is widely used in social sciences to measure the attributes of respondents. It is also widely used in an extensive range of variables in diverse areas of research. Farmers’ attitude towards Integrated Pest Management (IPM) [Pervez, *et al.* (2007)], athlete characteristics in sports [Brown, et al. (2007)], rural women’s awareness on indigenous knowledge [Pervez, *et al.* (2015)] or student perspective of engineering education [Li, et al. (2008)] are some example of this scale. Likert scale has a wide range of applications because its calculation is stress-free for researchers and it is easily understandable by the respondents. The responses can easily be quantified and are also applicable to different mathematical analysis. Respondents feel comfortable as they are not asked to provide a solid answer (i.e., yes or no) similar to the Boolean scale. Instead, they can reply to a different degree of agreements, hence such options help participants answer the responses conveniently.

Furthermore, the data can be code and accumulated quickly. Therefore, the Likert method is easy, efficient, and economical for researchers. Moreover, the measurements using the Likert scale demonstrate good reliability and researchers can collect a large database and analysis with minimum effort [Li (2013)].

On the other hand, in reality, attitudes are multidimensional, but Likert scale can provide only a single-dimensional option. Thus, sometimes, it is difficult to assess the actual attitude towards a statement. Furthermore, the scale seriously influences the respondents. Though sometimes an extreme opinion is accurate, people avoid providing such views hence the scale assumes equivalent differences among the scale points. But some social scientists like Cohen, *et al*. (2000) claimed the same differences between the scale points is illegitimate. Also, the Likert scale is made based on a closed format style [Hodge and Gillepie (2003)] which forces the respondent to answer [Li (2013)]. Such problems lead to the development of a new, more practical Likert scale.

Others found a more significant number of choices of response as a solution for these problems [Chang (1994); Russell and Bobko (1992). Albaum (1997) projected an alternative scale, which is designed with multiple stages. In this scale, researchers first measure the agreements (either agree or disagree) and then measure the intensity of their deals (strangeness and weakness). Hodge and Gillespie (2003) proposed a ten-point scale with values from 1 to 10. Almadani (2014) used this scale for assessment of the risk sources.

Li (2013) proposed a Fuzzy theory-based scale to overcome the existing limitations of the Likert scale. A problem with risk assessment is complicated as risks have two dimensions, e.g., the probability of certain events and the impacts. Evaluation of perceived risks is somewhat tricky by in traditional Likert scale. Furthermore, a scale with the same difference between consecutive scale points is problematic to measure the risks. Thus, the objective of the research is (i) to find out the application of Fuzzy-Likert scale to estimate the perceived risk, and (ii) to develop a structured questionnaire using a Fuzzy-Likert scale.

2. RESEARCH METHODOLOGIES

The research was conducted based on the secondary data sources such as published scientific articles, online reports, and online repositories. The researchers used content analysis to determine findings, discussion, conclusion and recommendation regarding the topic.

3. FUZZY LIKERT SCALE AND ITS STRENGTH IN RISK ASSESSMENT

The fuzzy set theory was first presented by Zadeh L.A. [Zadeh (1965)]. The set is extensively used in engineering science but limitedly in social science. Many social scientists found its full application in the survey research [e.g., Smithson (1987); Ragin (2000); Smithson and Verkuilen (2006); Rivza and Rivza (2013); Uddin (2012); Pervez (2018) and Pervez, *et al.* (2019)]. The fuzzy set can be used as a semi-quantitative scale which has extensive application in perceived risk assessment in agriculture [Portik and Pokoradi (2014)].

The Fuzzy Sets A simple example can explain about the fuzzy concept; for instance, 'he is tall' is fuzzy, because the term "tall" is not clearly defined. The term 'tall' is not clearly defined, and it has a different meaning to diverse people. We know that set means a collection of similar data. For a set of 'tall men,' we should first set a definition for 'tall.' Let, a 'tall man' is a person who 6 feet tall or more. With this definition, we can determine whether a person will or win not be on the set of 'tall men'. This kind of sharp-edged explanation works well in binary operations or mathematics. In fact, in the real world, this definition does not work everywhere correctly. This definition of the membership function is unable to find the difference between two persons of 6 feet and 7 feet respectively because according to the description, both the persons are tall. On the other hand, the difference between a man of 6 feet and a man of 5 feet and 11 inches is huge in the scale, though, in reality, their difference is only 1 inch, while, according to the definition one is tall, and the other is not.

The characteristic function is an example of a fuzzy set. Suppose A is a standard set in the universe U. Then the unique feature of A represented by 1_A is distinct by the following equation:

$$1_A(x) = \begin{cases} 1 & for\ x \in A \\ 0 & otherwise \end{cases} \quad \dots (3)$$

Thus, if $1_A(x) = 1$, we say that *x* is an element of the set *A* and if $1_A(x) = 0$, we say that *x* is not an element of *A*.

According to the traditional set theory, we assess a set membership if it represents the definition of the set. The fuzzy set theory enables to serve the partial possessions of an element to a set; therefore, the fuzzy set provides a wide range of values between 0 and 1. The following equation defines a fuzzy set R on a set A:

$$R = \{(x, R_A(x)): x \in A, R_A(x) \in [0,1]\} \quad \dots (4)$$

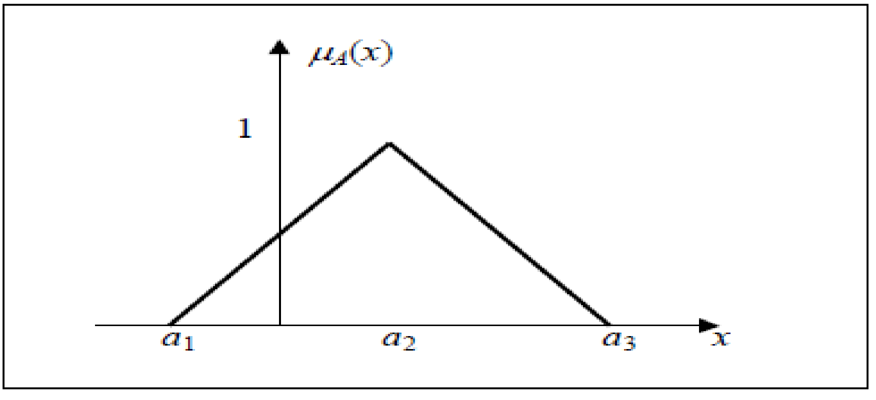
Here, $R_A(x)$ is a membership function; $R_A(x)$ represents the degree level in which an element (x) belongs to the fuzzy set (R).

Triangular fuzzy numbers and their operations Fuzzy numbers have quantitative values that are not precise. A fuzzy number can be obtained through the function of the fuzzy set domain. Each numerical value of a fuzzy set domain can get from a specific membership grade, where 0 is the smallest value, and 1000 can be the highest possible grade. Triangular Fuzzy Number (TFN) represents the fuzzy numbers, which are build up with three real numbers. for example, $A= (a_1, a_2, a_3)$. Here a_3 is the maximum value of the set A and a_1 is the minimum value. $\mu_A(x)$ represents the membership function of the fuzzy triangular set is embodied in the following equation:

$$\mu_A(x) = \begin{cases} 0 & ; \quad x < a_1 \\ \frac{x-a_1}{a_2-a_3} & ; \quad a_1 \le x \le a_2 \\ \frac{a_3-x}{a_3-a_2} & ; \quad a_2 \le x \le a_3 \\ 0 & ; \quad x > a_3 \end{cases} \quad \ldots (5)$$

TFN $A= (a_1, a_2, a_3)$ is demonstrated geometrically in figure 1. If the position of x is between a_1 and a_2, the value of x is larger, so that larger its membership function $x=a_2$. On the contrary, if the position of x in between a_2 and a_3, therefore, x is the smaller its membership function of membership and $x = a_3$ the degree of association is then 0.

Figure 1. Triangular Fuzzy Number



Due to the simple mathematical operation, the efficiency of the computation of TFN is very high. The actions of fuzzy number A and B can be done as follows:

Let, X = (x_1, x_2, x_3), B = (y_1, y_2, y_3)

$$X \oplus Y = (x_1 \oplus y_1, x_2 \oplus y_2, x_3 \oplus x_3) \quad \ldots (6)$$

$$X \otimes Y = (x_1 \otimes y_1, x_2 \otimes y_2, x_3 \otimes y_3) \quad \ldots (7)$$

For multiplication, division, and inversion of two fuzzy triangular numbers is generally not a triangular fuzzy number. As the difference is minimal, for simplicity of calculation, the results are also treated as a triangular fuzzy number [Habibi, *et al.* 2015).

Examples of some Fuzzy-Likert Scales

Li (2013) described the detailed procedure of the development of a Fuzzy-Likert scale. According to his description, the Fuzzy-Likert scale can be prepared by using the format of traditional scales. Before the development of a Fuzzy-Likert scale, an appropriate fuzzy spectrum is needed to develop for the fuzzification of the linguistic expressions. For this purpose, fuzzy spectrum development method or common fuzzy spectra is used extensively. Different Fuzzy-Likert scales using different fuzzy spectra. Table 1 is an example of a Fuzzy-Likert scale which is developed to find out the importance of a particular event(s).

Table 1. Triangular Fuzzy Numbers of a Five-point Likert Scale

Linguistic Scale	Characterization	Triangular Fuzzy Scale
Very unimportant	has no importance	(0, 0, 0.250)
Unimportant	has a very little importance	(0, 0.25, 0.5)
Moderately important	has some importance	(0.25, 0.5, 0.75)
Important	has importance	(0.5, 0.75, 1)
Very important	has very strong importance	(0.75, 1, 1)

Source: Habibi, *et al*. (2015), Pervez (2018), Pervez, *et al.* (2019).

Rivza and Rivza (2013) developed a fuzzy Triangular-Likert for assessment of the probability of the risks, presented in Table 2.

Table 2. Triangular Fuzzy Scale for Evaluation Risk Probability

Linguistic Scale	Characterization	Triangular Fuzzy Scale
Unlikely	Could happen only under rare Conditions	(0, 0.125, 0.25)
Seldom	Could happen though unlikely	(0.15, 0.30, 0.45)
Occasional	Could happen during one year	(0.35, 0.50, 0.65)
Likely	Could happen once in several months	(0.55, 0.70, 0.85)
Frequent	Mostly happens at least once a month	(0.75, 0.875, 1.0)

Source: Habibi, *et al*. (2015), Pervez (2018), Pervez, *et al.* (2019).

Similarly, using fuzzy numbers, a traditional Likert scale can be moderated according to the requirement of the researchers. There are some more uses of this scale; a seven-point fuzzy scale [Habibi *et al.* (2015)], for the occurrence of a failure and for the detection of a failure (fuzzy evaluation), the severity of failure [Wang, *et al*. (2009), Significance of risks [Rivza and Rivza, (2013)]. The fuzzy triangular scale for assessment the risk significance is shown in Table 3.

Table 3. Triangular Fuzzy Scale for Evaluation of the Significance of Risks

Linguistic Scale	Characterization	Triangular Fuzzy Scale
Negligible	Up to 1% from the total budget of the enterprise	(0, 0.0075, 0.015)
Minor	1-5% from the total budget of the enterprise	(0.005, 0.025, 0.055)
Moderate	5-10% from the total budget of the enterprise	(0.045, 0.0775, 0.11)
Critical	10-25% from the total budget of the enterprise	(0.09, 0.195, 0.30)
Catastrophic	Above 25% from the total budget of the enterprise	(0.20, 0.60, 1.0)

Source: Rivza & Rivza (2013), Pervez (2018), Pervez, *et al.* (2019).

Defuzzification of Fuzzy Numbers: To make a proper explanation, fuzzy numbers are needed to *defuzzify*. In the process, the fuzzy values are converted to a typical crisp; therefore, the data can be treated as a traditional non-fuzzy scale for using in statistical process. There are several methods for *defuzzification* process, for example, the MOM (Mean of Maxima), COA (Center of Area) method [Zimmermann (1996)]. In COA the centre value is the output; whereas in MOM method, the mean of the triangular values is the output. Thus the process is termed Mean of Maxima. Others calculate the way of the fuzzy values of a set to get *defuzzification* value [Rivza and Rivza (2013)]; the method is called the centroid method [Ross (2005)]. As the fuzzy number will use to measure the risks but the fuzzy numbers are not directly interpretable for analysis, thus for each fuzzy value, a scalar value is needed to calculate using the centroid method. For this purpose, MATLAB, Fuzzy Logic Toolbox Software can also be used.

Application of Fuzzy Number for Risk Assessment: As risk has two dimensions, risks can be measured with the multiplication of the probability of risk and its hazard. Therefore, the fuzzy values for risk probability and severity are needed to multiply [Meixner (2009)]. According to the equation 2, the two fuzzy functions of probability (Table 2) and significance (Table 3) are multiplied according to fuzzy multiplication rules (equation 7). Finally, the defuzzification process can be done - for each fuzzy value, a scalar value is calculated using the centroid method [Ross, (2005)]. Lastly, *defuzzification* score for a statement is used for risk [(Yu and Lee (2012); Kadir, *et al*. (2013); Pervez, (2018) Pervez, *et al.* (2019)].

Table 4. Risk Difuzzification

Linguistic Scale	Triangular Fuzzy Scale	Defuzzification Value
Unlikely with negligible loss	(0, 0.00187, 0.00375)	0.0019
Unlikely with minor loss	(0, 0.00687, 0.01375)	0.0069
Unlikely with moderate loss	(0, 0.01375, 0.02750)	0.0138
Unlikely with critical loss	(0, 0.03750, 0.0750)	0.0375
Unlikely with catastrophic loss	(0, 0.1250, 0.250)	0.125
Seldom with negligible loss	(0, 0.00337, 0.00675)	0.0034
Seldom with minor loss	(0.00075, 0.01275, 0.02475)	0.0128
Seldom with moderate loss	(0.00675, 0.02812, 0.04950)	0.0281
Seldom with critical loss	(0.01350, 0.07425, 0.1350)	0.074
Seldom with catastrophic loss	(0.030, 0.240, 0.450)	0.2400
Occasional with negligible loss	(0, 0.00487, 0.00975)	0.0049
Occasional with minor loss	(0.00175, 0.01875, 0.03575)	0.0188
Occasional with moderate loss	(0.01575, 0.04362, 0.07150)	0.0436
Occasional with critical loss	(0.03150, 0.12325, 0.1950)	0.1133
Occasional with catastrophic loss	(0.070, 0.360, 0.650)	0.3600
Likely with negligible loss	(0, 0.00637, 0.01275)	0.0064
Likely with minor loss	(0.00275, (0.02475, 0.05912,	0.0248
Likely with moderate loss	0.09350) 0.02475, 0.04675)	0.0591
Likely with critical loss	(0.04950, 0.15225, 0.2550)	0.1522
Likely with catastrophic loss	(0.110, 0.480, 0.850)	0.4800
Frequent with negligible loss	(0, 0.0075, 0.0150)	0.0075
Frequent with minor loss	(0.00375, 0.02937, 0.0550)	0.0294
Frequent with moderate loss	(0.03375, 0.07187, 0.110)	0.0719
Frequent with critical loss	(0.0675, 0.1837, 0.30)	0.1838
Frequent with catastrophic loss	(0.150, 0.5750, 1.00)	0.5750

Source: Rivza and Rivza (2013); Pervez (2018); Pervez, *et al.* (2019).

Designing a Structured Questionnaire for Risk Assessment with a Fuzzy-Likert Scale

Developing a questionnaire for assessment of risks must include the option for the probability of occurrence and their impacts. Therefore, the questionnaire is prepared with considering these two dimensions, shown in Table 5. The risk score for each item of risk can be obtained (defuzzification values from table 4) and the amount provides the perceived risk score of a particular item of a farmer. Then, the score of each element is needed to be added. If risk score of a farmer is high, it is clear he/she deserves more support from government or extension agents. This value also can express how much the farmer is affected by the risks. This kind of score can help the extension agents to find out the farmer who is in risky situation.

Table 5. An example of risk sources and choice options in the questionnaire

Production Risks	Probability of occurrence					Impact					Defuzzification value
	U	S	O	L	F	Neg	Min	Mod	Cri	Cat	
1. Scarcity of water	√						√				0.0069
2. Diseases attack				√						√	0.4800
3. Insect attack	√								√		0.0375

Note: U= Unlikely, S= Seldom, O= Occasionally, L= Likely, F= Frequent, Neg= Negligible, Min= Minor, Mod= Moderate, Cri= Critical, Cat= Catastrophic.

Finally, the researcher can use the score for statistical analysis. Table 5 shows a model questionnaire for calculation of production risk of farmers. Assume, there are three risk sources in the production risk category. The sources are a scarcity of water, disease attack and insect attack. A farmer gives his opinion on these issues. Therefore, we can easily get the defuzzification number for his opinion (Table 5). According to his opinion, we get the disease attack is the riskiest to him and the total risks score of the farmer is 0.0069 + 0.4800 + 0.0375= 0.5244. With this value, we can easily compare who is in the riskier situation and create the category of farmers according to risk. Finally, the value can be used in different statistical treatments.

4. CONCLUSION AND RECOMMENDATION

As many researchers around the world are keen to overcome the drawbacks of the traditional Likert scale; the Fuzzy-Likert scale can be a suitable alternative. Many researchers criticised that equal difference exists among the scale points. Therefore, researchers need a particular emphasis on scaling. Thus, Fuzzy-Likert scale may act as a solution for these limitations. Besides, Fuzzy-Likert scale is more rationally built and can modify according to the researchers' requirements. Nowadays, this scale is widely acceptable and researchers in social sciences are frequently using it. In Fuzzy-Likert scale, the difference between two consecutive scale points is not equal but rationally builds the problems and research objectives. Fuzzy-Likert scale is constructed by a combination of both qualitative and quantitative criteria. Thus, this scale acts as the bridge between the two paradigms in social science. Some researchers also found accurate results using the fuzzy-Likert scale in comparison with a Likert scale. Furthermore, a problem like perceived risk assessment is quite tricky with using the traditional Likert scale because risks are multi-dimensional. Using the Fuzzy-Likert scale helps measure perceived risk in different fields in social sciences.

REFERENCES

Albaum, G. (1997) The Likert Scale Revisited: An Alternate Version. *Journal of the Market Research Society*, 39, 331–349.

Almadani, M. I. N. (2014) Risk Attitude, Risk Perception and Risk Management Strategies: An Empirical Analysis of Syrian Wheat-Cotton and Pistachio Farmers. Ph.D. Dissertation, Georg –August University, Gottingen.

Bojadziev, G., and M. Bojadziev (1999) Fuzzy Logic for Business, *Finance and Management*. Danvers, MA: World Scientific Publishing.

Bowling, A. (1997) *Research Methods in Health*. Buckingham: Open University Press.

Brown, C. N., K. M., Guskiewicz, and J. Bleiberg (2007) Athlete Characteristics and Outcome Cores for Computerized Neuropsychological Assessment: A Preliminary Analysis. *Journal of Athletic Training*, 42, 515–524.

Burns, N., and S. K. Grove (1997) *The Practice of Nursing Research Conduct, Critique, & Utilization*. Philadelphia: W.B. Saunders and Co.

Chang, L. (1994) A Psychometric Evaluation of 4-poing and 6-point Likert-Type Scales In Relation To Reliability and Validity. *Applied Psychological Measurement*, 18, 205–215.

Cohen, L., L. Manison, and K. Morison (2000) *Research Methods in Education*, London: Routledge Falmer.

Crichton, D. (1999) The Risk Triangle. In J. Ingleton (Eds.), Natural Disaster Management (pp. 102-103). London: Tudor Rose.

Dallas, M. (2006) *Value and Risk Management a Guide to Best Practice*, Malden, MA: Blackwell Publications.

European Commission (2001) Risk Management Tools for EU Agriculture with a Special Focus on Insurance. European Commission working document, 2001. http://ec.europa.eu/agriculture/publi/insurance/ text_ en.pdf. (accessed on 06 June, 2015).

Habibi, A., F.F. Jahantigh and A. Sarafrazi (2015) Fuzzy Delphi Technique for Forecasting and Screening Items. *Asian Journal of Research in Business Economics and Management*, 5(2): 130-143.

Hardaker, J. B., R.B.M. Huirne, J.R., Anderson and G. Lien (2004) *Coping with Risk in Agriculture.* (2nd ed), Wallingford: CABI Publishing.

Harwood, Y., R. Heifner, K. Coble, J. Perry, and A. Somwaru (1999) Managing Risk in Farming, Concepts, Research and Analysis. Market and Trade Economics Division and Resource Economics Division, Economic Report No. 774, Washington: U.S. Department of Agriculture Agricultural (USDA).

Hillson, D., and R. Murray-Webster (2004) Understanding and Managing Risk Attitude. In Proceedings of 7th Annual Risk Conference, London, 2004.
http://www.isahp.org/2009Proceedings/Final_Papers/50_Meixner_Fuzzy_AHP_REV _ FIN. pdf (Accessed on 25 June 2015).

Hodge, D. R., and D. Gillespie (2003) Phrase Completions: An Alternative to Likert Scales. *Social Work Research*, 27, 45–55.

Jaffee S., P. Siegel and C. Andrews (2008) Rapid Agricultural Supply Chain Risk Assessment. Washington: Agriculture and Rural Development Department, World Bank.

Kadir, M. K.A., E. L. Hines, K. Qaddoum, R. Collier, E. Dowler, W. Grant, M. S. Leeson, D. Iliescu, A. Subramanian, K. Richards, Y. Merali, and R. M. Napier (2013) Food Security Risk Level Assessment : A Fuzzy Logic-Based Approach. *Applied Artificial Intelligence*, 27(1): 50-61.

Kirilenko, A.P., J. Alcamo, G.N. Golubev, N.M. Dronin, and M. Endejan (2004) Modeling the Impact Of Climate Changes On Agriculture in Russia. *Doklady Academii Nauk Geografia (Reports of Russian Academy of Sciences, Geography)*, 396(6): 819-822.

Li, Q. (2013) A Novel Likert Scale Based on Fuzzy Sets Theory. *Expert Systems with Applications*, 40, 1609–1618.

Li, Q., D. B. McCoach, H. Swaminathan, and J. Tang (2008) Development of an Instrument To Measure Perspectives Of Engineering Education Among College Students. *Journal of Engineering Education*, 97, 47–56.

Markowski, A., and M. S. Mannan (2008) Fuzzy Risk Matrix. *Journal of Hazardous Materials*, 159, 152~157. 10.1016/j.jhazmat.2008.03.055.

Meixner, O. (2009) Fuzzy AHP Group Decision Analysis And Its Application For The Evaluation Of Energy Sources. In: Proceedings of the 10th International Symposium on the Analytic Hierarchy/Network Process Multi-criteria Decision Making, University of Pittsburgh, Pittsburgh, Pennsylvania, USA. (Accessed on September 19, 2015).

Nguyen, N. C. (2007) Risk Management Strategies And Decision Support Tools for Dry Land Farmers in Southwest Queensland. Australia, PhD Thesis, University of Queensland, Gatton. Queensland.

Orr, M. G., and S. Ohlsson (2005) Relationship between Complexity and Liking as A Function of Expertise. *Music Perception*, 22, 580-583.

Pervez, A. K. M. K., M. F. Chowdhury, M. M. Rahman, and M. R. Amin (2007) Farmers Attitude Towards IPM for High-Value Crops Production. *Bangladesh J. Prog. Sci. & Tech.,* 5(2): 277-280.

Pervez, A. K. M. K., Q. Gao, and M. E. Uddin (2015) Rural Women’s Awareness On Indigenous Technical Knowledge: Case of Northern Bangladesh. *Anthropologist,* 21(3): 415-426.

Pervez, A.K.M.K. (2018) A Study of Risk Management Strategy for Hybrid Rice Production in Bangladesh. Thesis Diss., China Agricultural University.

Pervez, A.K.M.K., Q. Gao, andM.E. Uddin (2016) The Management of Agricultural Risk in Bangladesh: A Proposed Process. ***Asian** Journal of Agricultural Extension, Economics & Sociology*, 12(1): 1-13.

Pervez, K., E. Uddin, A. Shah, F. Prodhan, and M. Sheikh (2019) Fuzzy-Likert Scale Based Assessment of Marketing Risk Faced by The Hybrid Rice growers of Bangladesh. *Economics of Agriculture (Ekonomika poljoprivrede)*, 66(1): 9-22.

Pett, M. A. (1997) *Nonparametric Statistics for Health Care Research: Statistics for Small Samples and Unusual Distribution*. London: SAGE Publication.

Portik, T. and L. Pokoradi (2014) The Summarized Weighted Mean of Maxima and Its Application at The End of Risk Assessment Process. *Acta Polytechnica Hungarica*, 11:3, 167-180.

Ragin, C. C. (2000) *Fuzzy-Set in Social Science*. London: The University of Chicago Press, Ltd.

Renn, O. (2008) Concept of Risk: An Interdisciplinary Review. In: Proceedings of the ISA Conference, Barcelona, September 3-10, 2008. http://www.riskanduncertainty.net/TG04/Ortwin_Renn_concepts.pdf (Accessed on 10 September, 2019).

Rivza, S. Z. and P. Rivza (2013) Fuzzy-ANP Based Research On The Risk Assessment Of Biogas Production From Agricultural Biomass. In: Proceedings of the International Symposium on the Analytical Hierarchy Process, Kualalumpur, June 23-26, 2013.

Ross T.J. (2005) *Fuzzy Logic with Engineering Applications*. The New York City: John Wiley & Sons Ltd.

Russell, C. J., and P. Bobko (1992) Moderated Regression Analysis and Likert Scales: Too Coarse for Comfort. *Journal of Applied Psychology*, 77, 336–342.

Seal, M. (2007) Patient Advocacy And Advance Care Planning In The Acute Hospital Setting. *Australian Journal of Advanced Nursing*, 24, 29–37.

Smithson, M. and J. Verkuilen (2006) *Fuzzy Set Theory: Applications in the Social Sciences.* Quantitative Applications In The Social Sciences Series, CA: Sage, Belmont.

Smithson, M. J. (1987) *Fuzzy Set Analysis for the Behavioral and Social Sciences.* Springer-Verlag., New York.

Soussan, J. and W. L. Arriens (2004) Poverty and Water Security: Understanding How Water Affects the Poor. Asian Development Bank, Manila.

Uddin, M. F. (2012) Application of Fuzzy Logic In Sociological Research: An Instance Of Potential Payoff. *Bangladesh e-Journal of Sociology*, 9:2, 7-18.

Uebersax, J. S. (2006) Likert Scales: Dispelling the Confusion. Statistical Methods for Rater Agreement, Retrieved March 5, 2018, from http://john-uebersax.com/stat/likert.htm.

Wang, Y., K. Chin, G. K. K., Poon, and J. Yang (2009) Risk Evaluation in Failure Mode and Effects Analysis Using Fuzzy Weighed Geometric Mean. *Expert System with Application*, 36, 1195-1207

Yu, J. and S.A. Lee (2012) Conflict-risk Assessment Model for Urban Regeneration Projects Using Fuzzy-FMEA. *KSCE Journal of Civil Engineering*,16:7, 1093-1103

Zadeh, L.A. (1965) Fuzzy Sets. *Information and Control*, 8, 338-353.

Zimmermann, H.J. (1983) Using fuzzy Sets in Operational Research. *European Journal of Operational Research*, 13, 201–216.