International Journal of

Logistics Systems and Management

Volume 14 Number 1 February 1999

A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'

P. Senthil Kumar

PG and Research Department of Mathematics,
Jamal Mohamed College (Autonomous),
Tiruchirappalli, Tamilnadu, India
Email: senthilsoft_5760@yahoo.com
Email: senthilsoft1985@gmail.com

Abstract: In real-life decisions, usually we happen to suffer through different states of uncertainties. In order to counter these uncertainties, in this paper, the author formulated a transportation problem in which costs are triangular intuitionistic fuzzy numbers, supplies and demands are crisp numbers. In this paper, a simple method for solving type-2 intuitionistic fuzzy transportation problem (type-2 IFTP) is proposed and optimal solution is obtained without using intuitionistic fuzzy modified distribution method and intuitionistic fuzzy zero point method. So, the proposed method gives the optimal solution directly. The solution procedure is illustrated with the help of three real life numerical examples. Defect of existing results proposed by Singh and Yadav (2016a) is discussed. Validity of Pandian's (2014) method is reviewed. Finally, the comparative study, results and discussion are given.

Keywords: intuitionistic fuzzy set; type-2 intuitionistic fuzzy transportation problem; triangular intuitionistic fuzzy number; optimal solution.

Reference to this paper should be made as follows: Kumar, P.S. (2018) 'A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'', *Int. J. Logistics Systems and Management*, Vol. 29, No. 1, pp.102–129.

Biographical notes: P. Senthil Kumar is an Assistant Professor in PG and Research Department of Mathematics at Jamal Mohamed College (Autonomous), Tiruchirappalli, Tamil Nadu, India. He has six years of teaching experience. He received his BSc, MSc and MPhil from Jamal Mohamed College, Tiruchirappalli in 2006, 2008, 2010, respectively. He completed his BED in Jamal Mohamed College of Teacher Education in 2009. He completed PGDCA in 2011 in the Bharathidasan University and PGDAOR in 2012 in Annamalai University, Tamil Nadu, India. He has submitted his PhD thesis in the area of intuitionistic fuzzy optimisation technique to the Bharathidasan University in 2015. He has published many research papers in referred national and international journals like Springer, IGI Global, etc. He also presented his research in Elsevier Conference Proceedings (ICMS-2014), MMASC-2012, etc. His areas of interest include operations research, fuzzy optimisation, intuitionistic fuzzy optimisation, numerical analysis and graph theory, etc.

Reference to this paper should be made as follows:

Kumar, P.S. (2018) 'A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'', *Int. J. Logistics Systems and Management*, Vol. 29, No. 1, pp.102–129. DOI: [10.1504/IJLSM.2018.10009204](https://doi.org/10.1504/IJLSM.2018.10009204)

MLA

Kumar, P. Senthil. "A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'." *International Journal of Logistics Systems and Management* 29.1 (2018): 102-129. DOI: [10.1504/IJLSM.2018.10009204](https://doi.org/10.1504/IJLSM.2018.10009204)

APA

Kumar, P. S. (2018). A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'. *International Journal of Logistics Systems and Management*, 29(1), 102-129. DOI: [10.1504/IJLSM.2018.10009204](https://doi.org/10.1504/IJLSM.2018.10009204)

Chicago

Kumar, P. Senthil. "A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'." *International Journal of Logistics Systems and Management* 29, no. 1 (2018): 102-129. DOI: [10.1504/IJLSM.2018.10009204](https://doi.org/10.1504/IJLSM.2018.10009204)

Harvard

Kumar, P.S., 2018. A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'. *International Journal of Logistics Systems and Management*, 29(1), pp.102-129. DOI: [10.1504/IJLSM.2018.10009204](https://doi.org/10.1504/IJLSM.2018.10009204)

Vancouver

Kumar PS. A note on 'a new approach for solving intuitionistic fuzzy transportation problem of type-2'. *International Journal of Logistics Systems and Management*. 2018;29(1):102-29. DOI: [10.1504/IJLSM.2018.10009204](https://doi.org/10.1504/IJLSM.2018.10009204)

$$\mu_{\tilde{z}^I}(c) = \begin{cases} 0, & \text{for } c < 202, \\ \frac{c-202}{386}, & \text{for } 202 \leq c \leq 588, \\ 1, & \text{for } c = 588, \\ \frac{1256-c}{668}, & \text{for } 588 \leq c \leq 1256, \\ 0, & \text{for } c > 1256, \end{cases} \quad (3)$$

and

$$g_{\tilde{z}^I}(c) = \begin{cases} 1, & \text{for } c < 74, \\ \frac{588-c}{514}, & \text{for } 74 \leq c \leq 588, \\ 0, & \text{for } c = 588, \\ \frac{c-588}{796}, & \text{for } 588 \leq c \leq 1384, \\ 1, & \text{for } c > 1384. \end{cases} \quad (4)$$

7 Conclusions

The type-2 IFTPs are solved by the proposed method which differs from the existing methods namely, intuitionistic fuzzy modified distribution method and intuitionistic fuzzy zero point method. The main advantage of this method is that the obtained solution is always optimal. To apply this method, there is no necessity to have $(m + n - 1)$ number of non-negative allotted entries (i.e., basic feasible solution). Also, we need not test the optimality condition. It is applicable to type-1, type-2, type-3 and type-4 IFTPs. The proposed method can help decision-makers in the logistics related issues of real-life problems by aiding them in the decision-making process and providing an optimal solution in a simple and effective manner. Further, it can be served as an important tool for a decision-maker when he/she handles various types of logistic problems having different types of parameters.

References

- Aggarwal, S. and Gupta, C. (2014) *Algorithm for Solving Intuitionistic Fuzzy Transportation Problem with Generalized Trapezoidal Intuitionistic Fuzzy Number via New Ranking Method*, Cornell University, Ithaca, USA, arXiv preprint arXiv:1401.3353.
- Angelov, P.P. (1997) 'Optimization in an intuitionistic fuzzy environment', *Fuzzy Sets and Systems*, Vol. 86, No. 3, pp.299–306.
- Antony, R.J.P., Savarimuthu, S.J. and Pathinathan, T. (2014) 'Method for solving the transportation problem using triangular intuitionistic fuzzy number', *International Journal of Computing Algorithm, Integrated Intelligent Research (IIR)*, Chennai, Tamilnadu, India, Vol. 3, pp.590–605.
- Atanassov, K.T. (1983) *Intuitionistic Fuzzy Sets*, VII ITKR's Session, Sofia, June, Deposited in Central Sci.-Techn. Library of Bulg. Acad. of Sci., 1697/84, in Bulg.

- Atanassov, K.T. (1995) 'Ideas for intuitionistic fuzzy equations, inequalities and optimization', *Notes on Intuitionistic Fuzzy Sets*, Vol. 1, No. 1, pp.17–24.
- Atanassov, K.T. (1999) *Intuitionistic Fuzzy Sets: Theory and Applications*, Physica-Verlag, Heidelberg, New York.
- Ban, A. (2008) 'Trapezoidal approximation of intuitionistic fuzzy numbers expressed by value, ambiguity, and weighted expected value', *Notes on Intuitionistic Fuzzy Sets*, Vol. 14, No. 1, pp.38–47.
- Basirzadeh, H. (2011) 'An approach for solving fuzzy transportation problem', *Applied Mathematical Sciences*, Vol. 5, No. 32, pp.1549–1566.
- Bharati, S.K., Nishad, A.K. and Singh, S.R. (2014) 'Solution of multi-objective linear programming problems in intuitionistic fuzzy environment', in *Proceedings of the Second International Conference on Soft Computing for Problem Solving (SocProS 2012)*, 28–30 December 2012, Springer, India, January, pp.161–171.
- Biswas, A. and Modak, N. (2012) 'Using fuzzy goal programming technique to solve multiobjective chance constrained programming problems in a fuzzy environment', *International Journal of Fuzzy System Applications (IJFSA)*, Vol. 2, No. 1, pp.71–80, doi: 10.4018/ijfsa.2012010105.
- Bit, A.K., Biswal, M.P. and Alam, S.S. (1992) 'Fuzzy programming approach to multicriteria decision making transportation problem', *Fuzzy Sets and Systems*, Vol. 50, No. 2, pp.135–141.
- Burillo, P., Bustince, H. and Moledano, V. (1994) 'Some definitions of intuitionistic fuzzy number-first properties', in *Proceedings of the 1st Workshop on Fuzzy Based Expert System*, Sofia, Bulgaria, September, pp.53–55.
- Chakraborty, D., Jana, D.K. and Roy, T.K. (2015) 'A new approach to solve multi-objective multi-choice multi-item Atanassov's intuitionistic fuzzy transportation problem using chance operator', *Journal of Intelligent and Fuzzy Systems*, Vol. 28, No. 2, pp.843–865.
- Chanas, S. and Kuchta, D. (1996) 'A concept of the optimal solution of the transportation problem with fuzzy cost coefficients', *Fuzzy Sets and Systems*, Vol. 82, No. 3, pp.299–305.
- Chanas, S. and Kuchta, D. (1998) 'Fuzzy integer transportation', *Fuzzy Sets and Systems*, Vol. 98, No. 3, pp.291–298.
- Chanas, S., Delgado, M., Verdegay, J.L. and Vila, M.A. (1993) 'Interval and fuzzy extension of classical transportation problems', *Transportation Planning and Technology*, Vol. 17, No. 2, pp.203–218.
- Chanas, S., Kolodziejczyk, W. and Machaj, A. (1984) 'A fuzzy approach to the transportation problem', *Fuzzy Sets and Systems*, Vol. 13, No. 3, pp.211–221.
- Charnes, A. and Cooper, W.W. (1954) 'The stepping-stone method for explaining linear programming calculation in transportation problem', *Management Science*, Vol. 1, No. 1, pp.49–69.
- Chen, M., Ishii, H. and Wu, C. (2008) 'Transportation problems on a fuzzy network', *International Journal of Innovative Computing Information and Control*, Vol. 4, No. 5, pp.1105–1109.
- Cherian, L. and Kuriakose, S. (2009) 'A fuzzy economic production quantity model with capacity constraint: intuitionistic fuzzy optimization for linear programming problems', *The Journal of Fuzzy Mathematics*, Vol. 17, No. 1, pp.139–144.
- Chiang, J. (2005) 'The optimal solution of the transportation problem with fuzzy demand and fuzzy product', *J. Inf. Sci. Eng.*, Vol. 21, No. 2, pp.439–451.
- Dantzig, G.B. (1963) *Linear Programming and Extensions*, pp.140–144, Princeton Univ. Press, Princeton, New Jersey.
- Das, M. and Baruah, H.K. (2007) 'Solution of the transportation problem in fuzzified form', *Journal of Fuzzy Mathematics*, Vol. 15, No. 1, pp.79–95.
- Dubey, D. and Mehra, A. (2011) 'Linear programming with triangular intuitionistic fuzzy number', in *Proceedings of the 7th conference of the European Society for Fuzzy Logic and Technology*, Vol. 1, No. 1, pp.563–569, Atlantis Press.

- Ebrahimnejad, A. (2012) 'Cost efficiency measures with trapezoidal fuzzy numbers in data envelopment analysis based on ranking functions: application in insurance organization and hospital', *International Journal of Fuzzy System Applications (IJFSA)*, Vol. 2, No. 3, pp.51–68, doi: 10.4018/ijfsa.2012070104.
- Grzegorzewski, P. (2003a) 'Distance and orderings in a family of intuitionistic fuzzy numbers', in *Proceedings of the 3rd Conference of the European Society for Fuzzy Logic and Technology*, Zittau, Germany, September, pp.223–227.
- Grzegorzewski, P. (2003b) 'Intuitionistic fuzzy numbers', *Proceedings of the IFSA 2003 World Congress*.
- Guha, D. and Chakraborty, D. (2010) 'A theoretical development of distance measure for intuitionistic fuzzy numbers', *International Journal of Mathematics and Mathematical Sciences*, Hindawi Publishing Corporation, Nasr City, Cairo, Egypt, Vol. 2010, Article ID 949143, 25pp., doi: 10.1155/2010/949143..
- Gupta, G., Kumar, A. and Sharma, M.K. (2016) 'A note on 'a new method for solving fuzzy linear programming problems based on the fuzzy linear complementary problem (FLCP)', *International Journal of Fuzzy Systems*, Vol. 18, No. 2, pp.333–337.
- Hitchcock, F.L. (1941) 'The distribution of a product from several sources to numerous localities', *J. Math. Phys.*, Vol. 20, No. 2, pp.224–230.
- Hussain, R.J. and Kumar, P.S. (2012a) 'The transportation problem with the aid of triangular intuitionistic fuzzy numbers', *Proceedings in International Conference on Mathematical Modeling and Applied Soft Computing (MMASC-2012)*, Coimbatore Institute of Technology Vol. 1, pp.819–825.
- Hussain, R.J. and Kumar, P.S. (2012b) 'The transportation problem in an intuitionistic fuzzy environment', *International Journal of Mathematics Research*, Vol. 4, No. 4, pp.411–420.
- Hussain, R.J. and Kumar, P.S. (2012c) 'Algorithmic approach for solving intuitionistic fuzzy transportation problem', *Applied Mathematical Sciences*, Vol. 6, No. 80, pp.3981–3989.
- Hussain, R.J. and Kumar, P.S. (2013) 'An optimal more-for-less solution of mixed constraints intuitionistic fuzzy transportation problems', *Int. J. Contemp. Math. Sciences*, Vol. 8, No. 12, pp.565–576, <http://dx.doi.org/10.12988/ijcms.2013.13056>.
- Jana, B. and Roy, T.K. (2007) 'Multi-objective intuitionistic fuzzy linear programming and its application in transportation model', *Notes on Intuitionistic Fuzzy Sets*, Vol. 13, No. 1, pp.34–51.
- Klir, G.J. and Yuan, B. (2003) *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall, New York.
- Koopmans T.C. (1949) 'Optimum utilization of the transportation system', *Econometrica, Supplement: Report of the Washington Meeting*, July, The Econometric Society, Vol. 17, pp.136–146, doi: 10.2307/1907301, <http://www.jstor.org/stable/1907301>.
- Kumar, A., Kaur, A. and Gupta, A. (2011) 'Fuzzy linear programming approach for solving fuzzy transportation problems with transshipment', *J. Math. Model. Algor.*, Vol. 10, No. 2, pp.163–180.
- Kumar, P.S. (2016) 'PSK method for solving type-1 and type-3 fuzzy transportation problems', *International Journal of Fuzzy System Applications (IJFSA)*, Vol. 5, No. 4, Article 6, article in press.
- Kumar, P.S. and Hussain, R.J. (2014a) 'A systematic approach for solving mixed intuitionistic fuzzy transportation problems', *International Journal of Pure and Applied Mathematics*, Vol. 92, No. 2, pp.181–190.
- Kumar, P.S. and Hussain, R.J. (2014b) 'A method for finding an optimal solution of an assignment problem under mixed intuitionistic fuzzy environment', *Proceedings in International Conference on Mathematical Sciences (ICMS-2014)*, Published by Elsevier, Sathyabama University, ISBN: 978-93-5107-261-4: 417–421.

- Kumar, P.S. and Hussain, R.J. (2014c) 'New algorithm for solving mixed intuitionistic fuzzy assignment problem', *Elixir Appl. Math.*, Elixir publishers, Salem, Tamilnadu, India, No. 73, pp.25971–25977.
- Kumar, P.S. and Hussain, R.J. (2015a) 'Computationally simple approach for solving fully intuitionistic fuzzy real life transportation problems', *International Journal of System Assurance Engineering and Management*, Springer India, pp.1–12, doi: 10.1007/s13198-014-0334-2.
- Kumar, P.S. and Hussain, R.J. (2015b) 'A method for solving unbalanced intuitionistic fuzzy transportation problems', *Notes on Intuitionistic Fuzzy Sets*, Vol. 21, No. 3, pp.54–65.
- Kumar, P.S. and Hussain, R.J. (2016a) 'A simple method for solving fully intuitionistic fuzzy real life assignment problem', *International Journal of Operations Research and Information Systems (IJORIS)*, Vol. 7, No. 2, pp.39–61, doi:10.4018/IJORIS.2016040103.
- Kumar, P.S. and Hussain, R.J. (2016b) 'An algorithm for solving unbalanced intuitionistic fuzzy assignment problem using triangular intuitionistic fuzzy number', *The Journal of Fuzzy Mathematics*, Vol. 24, No. 2, pp.289–302.
- Li, D.F., Nan, J.X. and Zhang, M.J. (2010) 'A ranking method of triangular intuitionistic fuzzy numbers and application to decision making', *International Journal of Computational Intelligence Systems*, Vol. 3, No. 5, pp.522–530.
- Li, L., Huang, Z., Da, Q. and Hu, J. (2008) 'A new method based on goal programming for solving transportation problem with fuzzy cost', in *International Symposium on Information Processing*, May, pp.3–8.
- Liao, X. (2015) 'Decision method of optimal investment enterprise selection under uncertain information environment', *International Journal of Fuzzy System Applications (IJFSA)*, Vol. 4, No. 1, pp.33–42, doi:10.4018/IJFSA.2015010102.
- Lin, F.T. (2009) 'Solving the transportation problem with fuzzy coefficients using genetic algorithms', in *IEEE International Conference on Fuzzy Systems*, August, pp.1468–1473.
- Mahapatra, G.S. and Roy, T.K. (2009) 'Reliability evaluations using triangular intuitionistic fuzzy numbers, arithmetic operations', *International Scholarly and Scientific Research and Innovation*, Vol. 3, No. 2, pp.422–429.
- Mahapatra, G.S. and Roy, T.K. (2013) 'Intuitionistic fuzzy number and its arithmetic operation with application on system failure', *Journal of Uncertain Systems*, Vol. 7, No. 2, pp.92–107.
- Mitchell, H.B. (2004) 'Ranking intuitionistic fuzzy numbers', *International Journal of Uncertainty, Fuzziness and Knowledge Based Systems*, Vol. 12, No. 3, pp.377–386.
- Mohideen, S.I. and Kumar, P.S. (2010) 'A comparative study on transportation problem in fuzzy environment', *International Journal of Mathematics Research*, Vol. 2, No. 1, pp.151–158.
- Nagoor Gani, A. and Abbas, S. (2012) 'Intuitionistic fuzzy transportation problem', *Proceedings of the Heber International Conference on Applications of Mathematics and Statistics (HICAMS)*, pp 528–535.
- Nasseri, S.H. and Ebrahimnejad, A. (2011) 'Sensitivity analysis on linear programming problems with trapezoidal fuzzy variables', *International Journal of Operations Research and Information Systems (IJORIS)*, Vol. 2, No. 2, pp.22–39, doi:10.4018/joris.2011040102.
- Nayagam, V.L.G., Venkateshwari, G. and Sivaraman, G. (2008) 'Ranking of intuitionistic fuzzy numbers', in *Proceedings of IEEE International Conference on Fuzzy Systems*, Hong Kong, pp.1971–1974.
- Nehi, H.M. (2010) 'A new ranking method for intuitionistic fuzzy numbers', *International Journal of Fuzzy Systems*, Vol. 12, No. 1, pp.80–86.
- Nehi, H.M. and Maleki, H.R. (2005) 'Intuitionistic fuzzy numbers and its applications in fuzzy optimization problem', in *Proceedings of the 9th WSEAS International Conference on Systems*, Athens, Greece, July, pp.1–5.

- Nishad, A.K. and Singh, S.R. (2015) 'Solving multi-objective decision making problem in intuitionistic fuzzy environment', *International Journal of System Assurance Engineering and Management*, Vol. 6, No. 2, pp.206–215, doi: 10.1007/s13198-014-0331-5.
- Oheigeartaigh, M. (1982) 'A fuzzy transportation algorithm', *Fuzzy Sets and Systems*, Vol. 8, No. 3, pp.235–243.
- Pandian, P. (2014) 'Realistic method for solving fully intuitionistic fuzzy transportation problems', *Applied Mathematical Sciences*, Vol. 8, No. 113, pp.5633–5639.
- Pandian, P. and Natarajan, G. (2010) 'A new algorithm for finding a fuzzy optimal solution for fuzzy transportation problems', *Applied Mathematical Sciences*, Vol. 4, No. 2, pp.79–90.
- Parvathi, R. and Malathi, C. (2012) 'Intuitionistic fuzzy linear programming problems', *World Applied Sciences Journal*, Vol. 17, No. 12, pp.1802–1807.
- Pattnaik, M. (2015) 'Decision making approach to fuzzy linear programming (FLP) problems with post optimal analysis', *International Journal of Operations Research and Information Systems (IJORIS)*, Vol. 6, No. 4, pp.75–90, doi:10.4018/IJORIS.2015100105.
- Pramanik, S., Jana, D.K. and Maiti, M. (2013) 'Multi-objective solid transportation problem in imprecise environments', *Journal of Transportation Security*, Vol. 6, No. 2, pp.131–150.
- Pramila, K. and Uthra, G. (2014) 'Optimal solution of an intuitionistic fuzzy transportation problem', *Annals of Pure and Applied Mathematics*, Vol. 8, No. 2, pp.67–73.
- Rani, D. and Gulati, T.R. (2014) 'A new approach to solve unbalanced transportation problems in imprecise environment', *Journal of Transportation Security*, Vol. 7, No. 3, pp.277–287.
- Rani, D., Gulathi, T.R. and Amit Kumar (2014) 'A method for unbalanced transportation problems in fuzzy environment', *Indian Academy of Sciences, Sadhana*, Vol. 39, No. 3, pp.573–581.
- Saad, O.M. and Abbas, S.A. (2003) 'A parametric study on transportation problem under fuzzy environment', *Journal of Fuzzy Mathematics*, Vol. 11, No. 1, pp.115–124.
- Saati, S., Hatami-Marbini, A., Tavana, M. and Hajiahkondi, E. (2012) 'A two-fold linear programming model with fuzzy data', *International Journal of Fuzzy System Applications (IJFSA)*, Vol. 2, No. 3, pp.1–12, doi:10.4018/ijfsa.2012070101.
- Shabani, A. and Jamkhaneh, E.B. (2014) 'A new generalized intuitionistic fuzzy number', *Journal of Fuzzy Set Valued Analysis*, Vol. 2014, No. 1, pp.1–10, Article ID jfsva-00199, 10pp., doi: 10.5899/2014/jfsva-00199, <http://dx.doi.org/10.5899/2014/jfsva-00199>.
- Shankar, N.R., Saradhi, B.P. and Babu, S.S. (2013) 'Fuzzy critical path method based on a new approach of ranking fuzzy numbers using centroid of centroids', *International Journal of Fuzzy System Applications (IJFSA)*, Vol. 3, No. 2, pp.16–31, doi:10.4018/ijfsa.2013040102.
- Shaw, A.K. and Roy, T.K. (2012) 'Some arithmetic operations on triangular intuitionistic fuzzy number and its application on reliability evaluation', *International Journal of Fuzzy Mathematics and Systems*, Vol. 2, No. 4, pp.363–382.
- Singh, S. and Gupta, G. (2014) 'A new approach for solving cost minimization balanced transportation problem under uncertainty', *Journal of Transportation Security*, Vol. 7, No. 4, pp.339–345.
- Singh, S.K. and Yadav, S.P. (2016a) 'A new approach for solving intuitionistic fuzzy transportation problem of type-2', *Annals of Operations Research*, Vol. 243, No. 1, pp.349–363.
- Singh, S.K. and Yadav, S.P. (2015) 'Efficient approach for solving type-1 intuitionistic fuzzy transportation problem', *International Journal of System Assurance Engineering and Management*, Vol. 6, No. 3, pp.259–267.
- Singh, S.K. and Yadav, S.P. (2016b) 'Fuzzy programming approach for solving intuitionistic fuzzy linear fractional programming problem', *International Journal of Fuzzy Systems*, Vol. 18, No. 2, pp.263–269.
- Solaiappan, S. and Jeyaraman, K. (2014) 'A new optimal solution method for trapezoidal fuzzy transportation problem', *International Journal of Advanced Research*, Vol. 2, No. 1, pp.933–942.

- Srinivas, B. and Ganesan, G. (2015) 'Optimal solution for intuitionistic fuzzy transportation problem via revised distribution method', *International Journal of Mathematics Trends and Technology*, Vol. 19, No. 2, pp.150–161.
- Stephen Dinagar, D. and Palanivel, K. (2009) 'The transportation problem in fuzzy environment', *International Journal of Algorithms, Computing and Mathematics*, Vol. 2, No. 3, pp.65–71.
- Stephen Dinagar, D. and Thiripurasundari, K. (2014) 'A navel method for solving fuzzy transportation problem involving intuitionistic trapezoidal fuzzy numbers', *International Journal of Current Research*, Vol. 6, No. 6, pp.7038–7041.
- Sudhakar, V.J. and Navaneetha Kumar, V. (2011) 'A different approach for solving two stage fuzzy transportation problems', *Int. J. Contemp. Math. Sciences*, Vol. 6, No. 11, pp.517–526.
- Taha, H.A. (2008) *Operations Research: An Introduction*, 8th ed., Pearson Education, India.
- Varghese, A. and Kuriakose, S. (2012) 'Centroid of an intuitionistic fuzzy number', *Notes on Intuitionistic Fuzzy Sets*, Vol. 18, No. 1, pp.19–24.
- Zadeh, L.A. (1965) 'Fuzzy sets', *Information and Computation*, Vol. 8, No. 3, pp.338–353.