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An Information System for Risk-Vulnerability Assessment to Flood

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ABSTRACT

An exhaustive knowledge of flood risk in different spatial locations is essential for developing an effective flood mitigation strategy for a watershed. In the present study, a riskvulnerability analysis to flood is performed. Four components of vulnerability to flood: 1) physical, 2) economic, 3) infrastructure and 4) social; are evaluated individually using a Geographic Information System (GIS) environment. The proposed methodology estimates the impact on infrastructure vulnerability due to inundation of critical facilities, emergency service stations and bridges. The components of vulnerability are combined to determine an overall vulnerability to flood. The exposures of land use/land cover and soil type (permeability) to flood are also considered to include their effects on severity of flood. The values of probability of occurrence of flood, vulnerability to flood, and exposures of land use and soil type to flood are used to finally compute flood risk at different locations in a watershed. The proposed methodology is implemented for six major damage centers in the Upper Thames River watershed, located in the SouthWestern Ontario, Canada to assess the flood risk. An information system is developed for systematic presentation of the flood risk, probability of occurrence of flood, vulnerability to flood, and exposures of land use and soil type to flood by postal code regions or Forward Sortation Areas (FSAs). The flood information system is designed to provide support for different users, i.e., general public, decisionmakers and water management professionals. An interactive analysis tool is developed within the information system to assist in evaluation of the flood risk in response to a change in land use pattern.

KEYWORDS

Flood Management, Flood Risk, Geographic Information System, Risk Management, Vulnerability Analysis, Information System

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References

- [1] P. J. Floyd, "Reducing Flood Risks," *Floods and Flood Management*, 1992, pp. 419435.
- [2] E. J. Plate, "Flood Risk and Flood Management," *Journal of Hydrology*, Vol. 267, No. 12, 2002, pp. 211.
- [3] A. Becker and U. Gru?newald, "Disaster Management: Flood Risk in Central Europe," *Science*, Vol. 300, No. 5622, 2003, p. 1099.
- [4] D. P. Loucks, J. R. Stedinger, D. W. Davis and E. Z. Stakhiv, "Private and Public Responses to Flood Risks," *International Journal of Water Resources Development*, Vol. 24, No. 4, 2008, pp. 541553.
- [5] M. J. Purvis, P. D. Bates and C. M. Hayes, "A Probabilistic Methodology to Estimate Future Coastal Flood Risk Due to Sea Level Rise," *Coastal Engineering*, Vol. 55, No. 12, 2008, pp. 10621073.
- [6] R. J. Dawson, L. Speight, J. W. Hall, S. Djordjevic, D. Savic and J. Leandro, "Attribution of Flood Risk in Urban Areas," *Journal of Hydroinformatics*, Vol. 10, No. 4, 2008, pp. 275288.

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- [7] H. Apel, G. T. Aronica, H. Kreibich and A. H. Thielen, " Flood Risk Analyses—How Detailed do We Need to be?" *Natural Hazards*, Vol. 49, No. 1, 2009, pp. 7998.
- [8] P. Garrett, " Assessing Flood Risk," *Water Bull*, Vol. 355, 1989, p. 9.
- [9] B. Burrell and J. Keefe, " Flood Risk Mapping in New Brunswick: A Decade Review," *Canadian Water Resources Journal*, Vol. 14, No. 1, 1989, pp. 6677.
- [10] D. G. Morris and R. W. Flavin, " Flood Risk Map for England and Wales," *Report UK Institute of Hydrology*, 1996, p. 130.
- [11] D. D. Shrubsole, " Flood Management in Canada at the Crossroads," *Global Environmental Change Part B: Environmental Hazards*, Vol. 2, No. 2, 2000, pp. 6375.
- [12] J. W. Hall, R. J. Dawson, P. B. Sayers, C. Rosu, J. B. Chatterton and R. Deakin, " A Methodology for National scale Flood Risk Assessment," *Proceedings of the Institution of Civil Engineers: Water and Maritime Engineering*, Vol. 156, No. 3, 2003, pp. 235247.
- [13] J. I. Barredo, A. de Roo and C. Lavalle, " Flood Risk Mapping at European Scale," *Water Science and Technology*, Vol. 56, No. 4, 2007, pp. 1117.
- [14] S. L. Cutter, (Ed.) " American Hazardscapes: The Regionalization of Hazards and Disasters," *Joseph Henry Press*, Washington, D.C., 2001, p. 211.
- [15] S. L. Cutter, " Vulnerability to Environmental Hazards," *Progress in Human Geography*, Vol. 20, No. 4, 1996, pp. 529539.
- [16] S. Bender, " Development and Use of Natural Hazard Vulnerability Assessment Techniques in the Americas," *Natural Hazards Review*, American Society of Civil Engineers, 2002, pp. 136138.
- [17] L. Roy, R. Leconte, F. Brissette and C. Marche, " The Impact of Climate Change on Seasonal Floods of a Southern Quebec River Basin," *Hydrological Processes*, Vol. 15, No. 3, 2001, pp. 31673179.
- [18] N. Nirupama and S. Simonovic, " Increase in Flood Risk Due to Urbanization: A Canadian Example," *Natural Hazards*, Vol. 40, No. 1, 2007, pp. 2541.
- [19] M. MorrisOswald and S. Simonovic, " Assessment of the Social Impacts of Flooding for Use in Flood Management in the Red River Basin," *Report Submitted to the International Red River Basin Task Force*, International Joint Commission, Winnipeg, Manitoba, 1997. <http://www.ijc.org/php/publications/html/assess.html>
- [20] E. Enarson, " Women, Work, and Family in the 1997 Red River Valley Flood: Ten Lessons Learned," *Disaster Preparedness Resources Centre*, University of British Columbia, British Columbia, Canada, 1999.
- [21] E. Enarson and J. Scanlon, " Gender Patterns in Flood Evacuation: A Case Study in Canada' s Red River Valley," *Applied Behavioural Science Review*, Vol. 7, No. 2, 1999, pp. 103124.
- [22] Natural Hazard Center, " Evaluation of a Literature Review of the Social Impacts of the 1997 Red River Flood," *Report Submitted to the International Red River Basin Task Force*, International Joint Commission. University of Colorado, Boulder, Colorado, USA, 1999, p. 11.
- [23] P. Blaikie, R. Cannon, I. Davis and B. Wisner, " At Risk: Natural Hazards, People' s Vulnerability, and Disasters," *Routledge*, New York, 1994, p. 284.
- [24] P. M. Kelly and W. N. Adger, " Theory and Practice in Assessing Vulnerability to Climate Change and Facilitating Adaptation," *Climatic Change*, Vol. 47, No. 4, 2000, pp. 325352.
- [25] B. Montz and T. Evans, " GIS and Social Vulnerability Analysis," In: E. Gruntfest and J. Handmer, Eds., *Coping with Flash Floods*, Kluwer Academic Publishers, Netherlands, 2001, pp. 3748.
- [26] S. L. Cutter, J. T. Mitchell and M. S. Scott, " Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina," *Annals of the Association of American Geographers*, Vol. 90, No. 4, 2000, pp. 713737.
- [27] L. K. Flax, R. W. Jackson and D. N. Stein, " Community Vulnerability Assessment Tool Methodology," *Natural Hazards Review*, American Society of Civil Engineers, Vol. 3, No. 4, 2002, pp. 163176.
- [28] S. L. Cutter, B. J. Boruff and W. L. Shirley, " Social Vulnerability to Environmental Hazards," *Social Science Quarterly*, Vol. 84, No. 2, 2003, pp. 242261.

- [29] R. Blong, " A New Damage Index," *Natural Hazards*, Vol. 30, No. 1, 2003, pp. 123.
- [30] N. T. Carter, " Flood Risk Management: Federal Role in Infrastructure," CRS Report for Congress, 2005, <http://fpc.state.gov/documents/organization/56095.pdf>
- [31] J. Chakraborty, G. A. Tobin and B. E. Montz, " Population Evacuation: Assessing Spatial Variability in Geophysical Risk and Social Vulnerability to Natural Hazards," *Natural Hazards Review*, American Society of Civil Engineers, Vol. 6, No. 1, 2005, pp. 2333.
- [32] L. Rygel, D. O' Sullivan and B. Yarnal, " A Method for Constructing a Social Vulnerability Index: An Application to Hurricane Storm Surges in a Developed Country," *Mitigation and Adaptation Strategies for Global Change*, Vol. 11, No. 3, 2006, pp. 741764.
- [33] A. Werritty, D. Housto, T. Ball, A. Tavendale and A. Black, " Exploring the Social Impacts of Flood Risk and Flooding in Scotland," *Scottish Executive Social Research*, Edinburgh, 2007.
- [34] S. K. Sinnakaudan, A. Ab Ghani, M. S. S. Ahmad, and N. A. Zakaria, " Flood Risk Mapping For Pari River Incorporating Sediment Transport," *Environmental Modelling and Software*, Vol. 18, No. 2, 2003, pp. 119130.
- [35] J. Bai, C. Wang, Z. Niu, S. Qi and G. Li, " Utilizing Remote Sensed TM Images and Meteorological Data to Plan Flood Risk Area," *Proceedings of The International Society for Optical Engineering*, Vol. 5232, 2006, pp. 370 377.
- [36] F. Forte, L. Pennetta and R. O. Strobl, " Historic Records and GIS Applications for Flood Risk Analysis in the Salento Peninsula (Southern Italy)," *Natural Hazards and Earth System Science*, Vol. 5, No. 6, 2005, pp. 833844.
- [37] R. Abdalla, C. V. Tao, H. Wu and I. A. Maqsood, " GIS Supported 3D Approach for Flood Risk Assessment of the Qu' Appelle River, Southern Saskatchewan," *International Journal of Risk Assessment and Management*, Vol. 6, No. 46, 2006, pp. 440455.
- [38] D. G. Hadjimitsis, " The Use of Satellite Remote Sensing and GIS for Assisting Flood Risk Assessment—A case study of Agriokalamini Catchment Area in PaphosCyprus," *Proceedings of The International Society for Optical Engineering*, Vol. 6742, No. 67420Z, 2007.
- [39] K. Smith, " *Environmental Hazards: Assessing Risk and Reducing Hazards*," 3rd Edition, Routledge (Taylor & Francis Group), New York, 2001, p. 392.
- [40] J. Lowry, H. Miller and G. Hepner, " A GISBased Sensitivity Analysis of Community Vulnerability to Hazardous Contaminants on the Mexico/U.S. Border," *Photogrammetric Engineering & Remote Sensing*, Vol. 61, No. 11, 2005, pp. 13471359.
- [41] L. A. Varga, D. Radulescu and R. Drobot, " Romanian National Strategy for Flood Risk Management," *IAHS AISH Publication*, Vol. 323, 2008, pp. 7586.
- [42] H. Chang, J. Franczyk and C. Kim, " What is Responsible for Increasing Flood Risks? The Case of Gangwon Province, Korea," *Natural Hazards*, Vol. 48, No. 3, 2009, pp. 339354.
- [43] P. Tran, F. Marincioni, R. Shaw, M. Sarti and A. L. Van, " A Flood Risk Management in Central Viet Nam: Challenges and Potentials," *Natural Hazards*, Vol. 46, No. 1, 2008, pp. 119138.
- [44] S. Forster, B. Kuhlmann, K. E. Lindenschmidt and A. Bronstert, " Assessing Flood Risk for a Rural Detention Area," *Natural Hazards and Earth System Science*, Vol. 8, No. 2, 2008, pp. 311322.
- [45] M. Dilley, R. S. Chen, U. Deichmann, A. L. LernerLam, M. Arnold, J. Agwe, P. Buys, O. Kjekstad, B. Lyon and G. Yetman, " *Natural Disasters Hotspots: A Global Risk Analysis*," Synthesis Report, The World Bank, Washington, D.C., 2005.
- [46] M. Arnold, R. Chen, U. Deichmann, M. Dilley, A. LernerLam, R. Pullen and Z. Trohanis, " *Natural Disaster Hotspots: Case Studies*," Disaster Risk Management Series, No. 6, The World Bank, Washington, D.C., 2006.
- [47] UN, " *Internationally Agreed Glossary of Basic Terms Related to Disaster Management*," United Nations Department of Humanitarian Affairs, Geneva, 1992.
- [48] B. Merz and A. H. Thieken, " Flood Risk Analysis: Concepts and Challenges," *Osterreichische Wasser und Abfallwirtschaft*, Vol. 56, No. 34, 2004, pp. 2734.
- [49] EU, " *European Flood Directive: Richtlinie 2007/60/EG des Europ?ischen Parlaments und des Rates*

vom 23. Oktober 2007 über die Bewertung und das Management von Hochwasserrisiken,"
Amtsblatt der Europäischen Union, L288, pp. 2734.

- [50] W. Kron, " Flood Risk = Hazard?Values?Vulnerability," Water International, Vol. 30, No. 1, 2005, pp. 5868.
 - [51] S. Y. Wu, B. Yarnal and A. Fisher, " Vulnerability of Coastal Communities to SeaLevel Rise: A Case Study of Cape May County, New Jersey, USA," Climate Research, Vol. 22, No. 4, 2002, pp. 255270.
 - [52] Y. Huang, Y. Zou, G. Huang, I. Maqsood and A. Cha kma, " Flood Vulnerability to Climate Change through Hydrological Modeling: A Case Study of the Swift Current Creek Watershed in Western Canada," Water International, Vol. 30, No. 1, 2005, pp. 3139.
 - [53] A. Hebb and L. Mortsch, " Floods: Mapping Vulnerability in the Upper Thames Watershed under a Changing Climate," Project Report XI, University of Waterloo, 2007, pp. 153.
 - [54] R. Grosshans, H. Venema and S. Barg, " Geographical Analysis of Cumulative Threats to Prairie Water Resources: Mapping Water Availability, Water Quality, and Water Use Stresses," International Institute for Sustainable Development, Winnipeg, Manitoba, 2005, p. 40.
 - [55] M. Helsten and D. Davidge, " Flood Damage Estimation in the Upper Thames River Watershed CFCAS Project: Assessment of Water Resources Risk and Vulnerability to Changing Climatic Conditions," Project Report VII, Upper Thames River Conservation Authority, 2005, pp. 146.
 - [56] H. Apel, A. H. Thielen, B. Merz and G. A. Bloßchl, " Probabilistic Modelling System for Assessing Flood Risks," Natural Hazards, Vol. 38, No. 12, 2006, pp. 79100.
- W. Feller. An Introduction to Probability Theory and its Applications. 3rd Edition, John Wiley and