

An Open Access Framework for Urban Flood Vulnerability Assessment: A Case study in Thailand

Aahlaad Musunuru¹, Nitin Kumar Tripathi¹, Dr Indrajit Pal², Salvatore Viridis¹, Chitrini Mozumder¹

¹Remote Sensing and GIS (RS&GIS), Asian Institute of Technology (AIT) P.O. Box 4, Khlong Luang, Pathumthani 12120, Bangkok, Thailand

²Disaster Preparedness, Mitigation and Management (DPMM), Asian Institute of Technology (AIT) P.O. Box 4, Khlong Luang, Pathumthani 12120, Bangkok, Thailand.

E-mail: st119379@ait.asia, nitinkt@ait.asia, indrajit-pal@ait.asia, viridis@ait.asia, chitrini@ait.ac.th

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Abstract

Ko rain is a Tambon (sub-district) in the historical city of Ayutthaya which is existing on the northern side of Bangkok, the capital of Thailand. It has a long history of flooding events with the extensive inundation of buildings and infrastructure. In this study, we developed information consisting of flood-vulnerable structures such as buildings and roads that are highly affected by floods in the Ko rain tambon using Remote sensing and GIS techniques. The buildings and roads are extracted by using Object-based classification, a commonly used method for Land-use and Land-cover Maps generation. A set of data for the history of floods and flood inundation data of Ko rain tambon was collected from the reliable sources, including GISTDA, Digital Globe. The spatial data has been analyzed through the object-based classification method to identifying the vulnerability of urban land use classes like residential, commercial, educational institutions, and other urban features necessary to support the local communities. A web application is designed in the arc story maps using all the land use information and the vulnerability maps generated in the previous step. The dashboard designed in the google sheets is imported into the ArcGIS story for a comprehended and complete information on vulnerability in Ko rain. This will help to monitor the data regularly for the government authorities and land use planners for improving the resilience of the city. The maps which are present in the web application can be updated regularly by the municipality or GIS department of Ayutthaya.

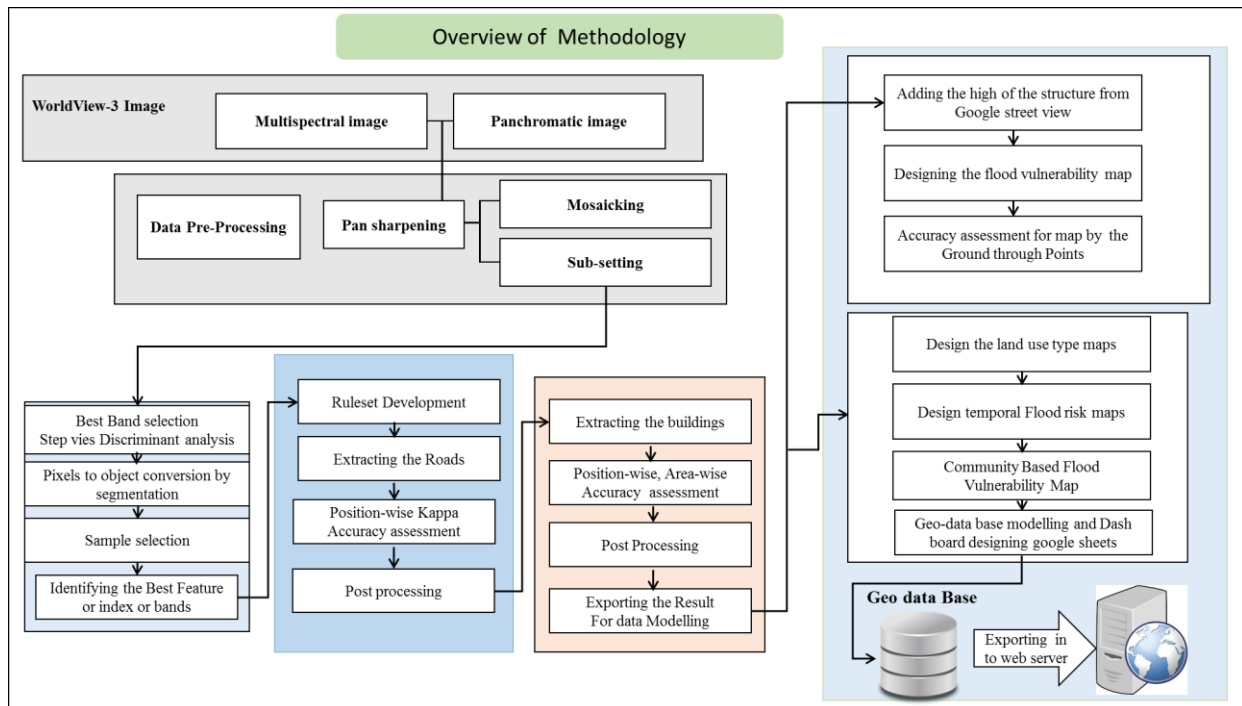
Floods are one of the major disasters which had affected a huge number of people, especially in the Asian Pacific nations. This impact is very high in the urban environment. Increase in extreme climate change and rainfall are the activities that require attention in the urban flood Management especially in the developing countries like Thailand.

The primary objective of this study is to extract the urban features by using object-based classification which is vulnerable to floods such as residential buildings, commercial buildings, institutional buildings, roads etc., and to create a geodatabase for flood vulnerability for Ko-rain tambon. The main scope of this research is to classify the urbanization in various groups and to analyze the temporal impact on the urban structures. The vulnerability maps and the geodatabase which are used in this research are helpful in the various rescue operations and sustainable city planning. The maps and the database can be updated regularly.

The below figure shows the overall methodology in this research. The overall methodology is divided into 3 parts.

- Image Analysis
- Flood Vulnerability Assessment

- Geodatabase Development



This study analyzed the urban flood vulnerability maps with 90% accuracy. Apart from this, a web GIS module was designed for sharing the data with the decision makers. The flood analysis revealed that 2006, 2011-year floods inundated high number of buildings.

For segmentation adjusting scale shape and compactness is done by various trial and error approaches. For this, an automatic approach is recommended for segmentation. For analyzing the vulnerability of structure, only height is considered. Apart from that, age and material of the structure are some of the important factors that are not considered for analyzing the vulnerability. Inclusion of the depth of flood inundation, in each database helps to analyze the flood risk in each community. For vulnerability area mapping, elevation is one of the important factors which is to be considered for vulnerability area mapping.

References

- and, C. S., Vanjare, A., Omkar, S. N., Senthilnath, J., Mani, V., & Diwakar, P. G. (2016). Flood Assessment using Multi-temporal Modis Satellite Images. *Procedia Computer Science*, 89, 575–586. <https://doi.org/10.1016/j.procs.2016.06.017>
- As-syakur, A. R., Adnyana, I. W. S., Arthana, I. W., & Nuarsa, I. W. (2012). Enhanced built-UP and bareness index (EBBI) for mapping built-UP and bare land in an urban area. *Remote Sensing*, 4(10), 2957–2970. <https://doi.org/10.3390/rs4102957>
- Benz, U. C., Hofmann, P., Willhauck, G., Lingenfelder, I., & Heynen, M. (2004). Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. *ISPRS Journal of Photogrammetry and Remote Sensing*, 58(3–4), 239–258. <https://doi.org/10.1016/j.isprsjprs.2003.10.002>
- Blaschke, T. (2004). Object-based contextual image classification built on image segmentation. *2003 IEEE Workshop on Advances in Techniques for Analysis of Remotely Sensed Data*, (May), 113–119. <https://doi.org/10.1109/WARSD.2003.1295182>
- Costa, H., Foody, G. M., & Boyd, D. S. (2018a). Supervised methods of image segmentation accuracy assessment in land cover mapping. *Remote Sensing of Environment*, 205(December 2017), 338–351. <https://doi.org/10.1016/j.rse.2017.11.024>
- Costa, H., Foody, G. M., & Boyd, D. S. (2018b). Supervised methods of image segmentation accuracy assessment in land cover mapping. *Remote Sensing of Environment*, 205(November 2017), 338–351. <https://doi.org/10.1016/j.rse.2017.11.024>
- Dey, V. (2011). a Supervised Approach for the Estimation of Parameters of Segmentation and Its Application in Building. *Geodesy and Geomatics Engineering, Master of*(278).
- DigitalGlobe. (2014). WorldView-3, 2. Retrieved from http://www.digitalglobe.com/sites/default/files/DG_WorldView3_DS_2014.pdf
- Juice. (2009). A Guide to Creating Dashboards People Love to Use. *Juice Analytics*, (November 2009), 1–11. Retrieved from <http://www.juiceanalytics.com/poster/>
- Jular, P. (2017). The 2011 Thailand Floods in The Lower Chao Phraya River Basin in Bangkok Metropolis The 2011 Thailand Floods in The Lower Chao Phraya River Basin in. Retrieved from http://www.gwp.org/globalassets/global/toolbox/case-studies/asia-and-caucasus/case-study_the-2011-floods-in-chao-phraya-river-basin-488.pdf
- Kang, J., Körner, M., Wang, Y., Taubenböck, H., & Zhu, X. X. (2018). Building instance classification using street view images. *ISPRS Journal of Photogrammetry and Remote Sensing*. <https://doi.org/10.1016/j.isprsjprs.2018.02.006>
- Krebs, W. (2010). Trimble's eCognition Product Suite, (October).
- Li, M., Stein, A., Bijker, W., & Zhan, Q. (2016). Urban land use extraction from Very High Resolution remote sensing imagery using a Bayesian network. *ISPRS Journal of Photogrammetry and Remote Sensing*, 122, 192–205. <https://doi.org/10.1016/j.isprsjprs.2016.10.007>
- Liu, Y., & Ngan, K. N. (2006). Embedded wavelet packet object-based image coding based on context classification and quadtree ordering. *Signal Processing: Image Communication*, 21(2), 143–155. <https://doi.org/10.1016/j.image.2005.09.001>
- Mongkonkerd, S., Hirunsalee, S., Kanegae, H., & Denpaiboon, C. (2013). Comparison of Direct Monetary Flood Damages in 2011 to Pillar House and Non-pillar House in Ayutthaya, Thailand. *Procedia Environmental Sciences*, 17, 327–336. <https://doi.org/10.1016/j.proenv.2013.02.045>



Masters student in Remote Sensing and Geographic Information Systems (GIS) in Asian Institute of Technology, Thailand. Done my research on urban flood vulnerability mapping using geographical information system. I have done my bachelors degree in Civil Engineering and I have done my thesis on building designing. I want to continue my research and gain more knowledge in Remote Sensing and Geographical information systems. For that, I am currently looking for PHD opportunity. I am so interested doing my research in disaster management for sustainable city planning and development, by using remote sensing and geographical information system. I have completed a course on 'Climate change and applications of satellite generated atmospheric and climate data'. I have volunteered 2 international workshops; one is 'Natural and nature based flood management: A green guide' and the other one is 'Disaster resilience and business continuity planning'. I published a poster in Asian Pacific National Conference, Thailand. I am currently working on a project on flood risk management.



Prof. Nitin Kumar Tripathi PhD in Remote Sensing, Indian Institute of Technology Kanpur India. Professor in the field Geographical Information System at Asian Institute of Technology, in Thailand. Prof. Tripathi started his teaching career after completion of his Masters in IIT Kharagpur. Prof. Tripathi has more than 25 years of experience in teaching and training. Prof. Tripathi authored and edited 12 books and more than 100 research articles in international and national conferences, international journals, and book chapters. Prof. Tripathi is expert in GIS and Health GIS. Prof. Tripathi is Director for unified programs and Thailand Alumina Association. Prof. Tripathi got so many awards. Prof. Tripathi is one of the directors in SCINDA project. Prof. Tripathi done so many Germany projects as a main member in the application of GIS, Health and Environment, RFID and Location Based interests and other academic activities which carried out in current Services.



Dr Indrajit Pal presently working as Assistant Professor at Disaster Preparedness, Mitigation and Management at Asian Institute of Technology, Thailand. Prior to his present assignment, he was served as faculty member at Centre for Disaster Management at Lal Bahadur Shastri National Academy of Administration, Mussoorie, India for more than eight years. Dr Indrajit Pal holds PhD on Seismotectonic and Earthquake Hazard Assessment, two master's degree, one in Applied Geology and another in Sociology with urban sociology specialization. Dr Pal also holds a Diploma in Management. Dr Pal having more than 15 years of experience on teaching, training, research, curriculum development, advocacy, consultancy primarily focused on Disaster Governance, Risk Management, Incident Command System, Disaster Risk Reduction, Hazard and Risk Assessment, GIS & Remote Sensing applications, Climate Change Adaptation and disaster risk management, Public Health Risk and Private Sector Risk Resilience etc. Dr Pal authored and edited six books and published more than 55 research articles in national international journals, conferences and book chapters. In 2017 Dr Pal has been recognized as "IRDR Young Scientists" by Integrated Research on Disaster Risk, Beijing, China and Board of Directors Member of Global Alliance of Disaster Research Institutes (GADRI), JAPAN.



Dr. Salvatory Verities, Assistant Professor in Remote Sensing and Geographical Information System at Asian Institute of Technology, Thailand. I worked at University of Nottingham Malaysia and Crops For the Future Research Centre. My formal background is in Applied Geological Sciences and Remote Sensing. Educated at Università degli studi di siena. Specialization: My recent and current research interest centre upon Geo-Information and Earth Observation Science to assess and evaluate past, present and future changes of anthropogenic origin as well as their effects on natural and non-natural physical/human environment. For my research, I combine and integrate a range of field-based, remote/proximal sensing techniques and advanced geo-spatial modelling. I look at natural and non-natural processes from the field- to the landscape-scale and on a variety of timescales, ranging from seasonal to decadal processes. Moreover, I certainly like to understand the dynamics of physical landscapes without neglecting the social and human dimension of geographical problems.



Dr Chitrini Mozumder has more than 10 years of experience in the field of remote sensing and Geographic Information Systems (GIS). Currently, she is working as a senior research specialist in Remote Sensing and GIS Department in Asian Institute of Technology (AIT). Prior to joining AIT, she has worked in Sultan Qaboos University, Sultanate of Oman as a Postdoctoral research fellow. She obtained her doctorate from AIT and Master and Bachelor of Engineering from National Institute of Technology Warangal, India and Assam Engineering College, India respectively. Her research interests include Remote Sensing and GIS applications in environmental monitoring and management, Land use change analysis and modelling, spatial analysis and decision support. Her key research projects include Sustainable flow

in large Indian river the Ganges, Aquaculture Site Selection and management in Nearshore Ocean in Oman, Deepor Beel Ramsar wetland management using a scenario-based geospatial approach. She has been involved in several pieces of training and workshops related to Remote Sensing and GIS applications in Thailand, India, and Oman.