Problem-based Learning As A Pedagogy For Individual Students - Quantifying The Long-term Effects of Land Subsidence and Rising Sea Levels In Coastal Areas For Greater Student Engagement

Dr. Sanjay Tewari, Missouri University of Science & Technology

Dr. Tewari is Assistant Teaching Professor of Civil Engineering at the Missouri University of Science & Technology, Rolla, MO. Prior to joining Missouri S&T, he worked as Assistant Professor at Louisiana Tech University. He earned his Bachelor of Engineering (Civil Engineering) and Master of Technology (Chemical Engineering) in India. He later joined Texas A&M University and earned his Doctor of Philosophy in Civil (Environmental) Engineering. His research efforts are focused on drinking water quality and issues related to treatment of wastewater using physical, chemical, biological and electro-chemical/kinetic processes. His recent research efforts have been in the area of application of geographic information systems to environmental management and sustainability, causes/effects of salinity in soils and corrosion of metal pipes. Dr. Tewari has keen interest in STEM education, improving diversity in STEM areas, inclusion of hands-on and digital tools in curriculum.

Problem-based Learning As A Pedagogy For Individual Students - Quantifying The Long-term Effects of Land Subsidence and Rising Sea Levels In Coastal Areas For Greater Student Engagement

1.0 Introduction

Course based class discussions usually are limited to course syllabus and topics of lectures because of time constraint of class/lab periods. Motivated students refer to textbooks and continue discussions with faculty to learn at deeper level. However, discussions alone are not the suitable way of learning and for that reason the motivating factors for some students. Students with strong inclination towards visual and experiential learning i.e. learning through reflection on doing, learn better when discussions pave way to a more visual and experiential phase [1] – [5]. The author has been involved in previous studies focused on making students learning activities more hands-on and experiential among undergraduate students [6], [7]. The overall learning of these students can be made more interactive when they are challenged or tasked to solve a problem with supervised guidance. This paper focuses on pedagogical aspect of problem-based learning and its application for greater student engagement in quantifying the long-term effects of land subsidence and rising sea levels in coastal or littoral areas.

Studying the effects of sea level rise gets complicated when long-term land subsidence is also considered. Students usually get confused when tasked to extrapolate these effects over long duration in future because of complicated issue of “sinking” reference datum and rising sea and resultant extent of land estimated to be inundated. This problem presents a challenge that requires creating spatial layers of water inundation delineating areas that will be under water in next several decades based on rising sea levels. The land lost because of rising sea levels would need a correction in terms of datum and land that is sinking over a long period. The task becomes even more challenging because it would need a large amount of real-life data from relevant government websites. The data would need to be downloaded, processed, transformed and interpolated before it could be used in a meaningful projection of seawater inundation over coastal land. Class discussions usually are insufficient and usually require use of this type problem as a class or term project, if course structure allows it. However, not many courses would have flexibility to have a term project of this kind. However, this kind of a project can be used as a special topic/problem class as an elective if degree plan allows it.

Not many students usually take on for this kind of challenge outside class to gain a better understanding of the concept and learn needed skills. However, if a spark of curiosity is provided, the task of recruiting gets easier for this kind of non-course based but relevant learning. This kind of learning gets even more challenging when student is a non-traditional undergraduate student. Cross [8] defined the nontraditional student as an adult who returns to school full- or part-time while maintaining responsibilities such as employment, family, and other responsibilities of adult life. These students also may be referred to as "adult students," "re-entry students," and "adult learners." This paper outlines the author’s experience on challenging a non-traditional student for problem-based learning. It also provides a detailed methodology that was followed by the student under author’s supervision and guidance for quantifying the long-term effects of land subsidence and rising sea levels in coastal areas using data available at various government websites and ArcGIS as a tool. This paper takes account of teaching-learning activities over a longer than usual (one semester) duration because this study was expanded to accommodate project funding secured during this period.

2.0 The Student

The student involved in this study can be classified as “adult learner” or “non-traditional student”. Prior to enrolling at Louisiana Tech University for an undergraduate degree in Geographic Information Science, student worked in United States Military for about seven years. While maintaining a status of fulltime enrollment and working on this study and off-campus technical job, student was also acting as a single parent. Initial discussions between the student and the author were solely focused on assessment of student’s technical background and his desire to be a part of experiential learning focused on effects of coastal land subsidence and rising sea. Author also wanted to make sure that student’s academic and personal commitments would allow for this kind of experience. The expected workload and timelines were also set during this discussion. The student graduated in May 2018.

3.0 Basis of Study

The study was focused on two aspects - 1) experiential learning involved in problem-based project related to estimations of long-term effects of coastal land subsidence and rising sea; and 2) pedagogical aspects of student-teacher interaction as a part of this study. The importance of experiential learning in curriculum and its benefits for students have been discussed in details in published literature. However, experiential learning only becomes effective if it is applied in an appropriate way. The author believes that this effectiveness is directly related to a sound understanding of the theory, supporting the learning.

The technical merit of the topic and its relevancy in today’s climate also played a role in topic selection for this study. The cause of the global warming and its relationship with change in global sea level is much debated. This study did not focus on that aspect. The project was focused on the problem at hand i.e. how to quantify the effect of two unrelated variables (coastal land subsidence and change in sea-level) on extent of land that will be lost. The expected outcomes of this study were outlined at the start of the project. The problem was challenging enough in terms of technical difficulty, skills needed for the proposed approached to solve the problem, and the time needed for the completion. Student and the author both set forth their expectations during initial discussion from their perspectives.

4.0 Pedagogical Aspects

Main pedagogical aspects remain same even for problem-based learning with individual students. Some of the main aspects pertaining to this study are discussed here briefly.

4.1 Selection, design and delivery of challenge/learning activity

The section aspect of the challenge/learning activity is already discussed in “Basis of Study” section. However, the designing of challenge/learning activities that deliver specific learning objectives in an engaging way requires skills and thoughtful planning. Educators usually prepare for their courses to be taught in a formal class environment. There is a new emphasis on designed learning activities produced by specialist course designers. These designed learning activities are being automatically integrated with learning management software for various courses. However, for a technically complex topic like this one, the educators cannot rely on pre-designed activity. The design of the activity should be flexible enough for individual student to have own pace of learning and flexibility to explore technical challenge catching student’s attention. In this study, initially weekly meetings were scheduled but the frequency was adjusted as needed based on participants’ schedules and level of difficulty of various stages of the problem. Sometimes, the teaching-learning took places over electronic communications with student work being assessed and returned through emails and discussion taking place over phone calls.

4.2 Joint productive activity

For learning to occur, effectively educators and students must work together for a common goal. This makes them equally motivated to assist one another. In this specific context of one-to-one problem-based learning for an individual student, providing assistance is the general definition of teaching. The joint productive activity results in maximized learning for students and equally rewarding for the educators. Working together on a problem allows scholarly conversation in informal setting without getting worried about the grades helps student learn freely and results in greater student engagement. This kind of mentoring and learning in action is more effective than a formal class with many students. The early part of the study was focused on exploratory discussions, which led to individual work assignments for students and pedagogical assignments to direct student towards the solution using student’s own approach made easier with scholarly discussions. Soon, this started to result in a joint productive activity.

4.3 Technical language development

The language development is one aspect of this study that was not perceived at the start. However, as the educator and student both made progress on the problem, it was evident that the educator was as much involved in technical language development as much he was in technical aspects of the problem related to land subsidence and rise in sea level. The educator responded to student’s questions in a more scholarly way with technical topic-related vocabulary inspiring students to mimicking educator’s style in oral and written communications. The educator also assisted students with writing development through eliciting, probing, restating, clarifying, and questioning in a purposeful manner student’s written reports in early part of the study and manuscripts in later parts of the study. As a result, there was a significant improvement in student’s ability to write and communicate. Prior to this student, student did not have any experience of writing for publication. However, student later published multiple papers and posters. He even made multiple technical presentations at local, regional and national level.

4.4 Praxis or integration of theory and practice

Students who have trouble understanding and learning by listening and reading, have far easier time in learning by doing things. The integration of theory in actionable educational material provides these students maximum learning opportunity. It is where students are most active and where most learning is taking place. “What”, “why”, and “how” are some of the words that educators should keep in mind for any problem-based learning activity. Student should be able to analyze the problems and identify “what” is the main problem and “what” needs to be done to solve it. The integration of theory with the hands-on and experiential learning would help students in answering “why” the problem is there and “why” the proposed solution may work. Skills taught or gained to implement the proposed solution teaches them the “how” part of practice.

4.5 Evaluation, correction and interpretation

This kind of teaching requires constant evaluation and the correction. Most of it takes place during the discussion part and some takes place during implementation of the proposed solution of the problem. This is a “never-ending” cycle that does not stop until the final product of the project. Corrections are done verbally, in written reports, in drawings, or written-codes. Students are good at getting things done once they understand how to do them. However, interpreting the results requires a greater understanding of the concept and the process used. A greater emphasis should be on understanding the results well enough for students to interpret them and come up with meaningful conclusions. For this to happen, educator should flip the role of educator-student relationship towards the end of the activity. By asking inquisitive questions, direct students to think at higher level for them to understand the complex results well enough to interpret them in simple manner. Towards the end of the study author let the student take the lead and the ownership of the project.

5.0 Technical Approach

Initially, the coastal area of Louisiana was chosen as the study for this problem-based learning. Here, technical aspects of the problem and the approach adopted to come up with desired solution is discussed. Spatial land subsidence rate was used with the rate of the sea-level rise to arrive at projected future (for 100 years in interval of 10 years) water elevation over land. The projected shoreline was defined by connecting the points with zero water elevation over land. This provided a good estimate of land lost to seawater inundation. ArcGIS Spatial Analysts extension was used to create projected inundation shapefiles for various periods. To make this activity even more complicated one could choose infrastructure located in coastal regions such as ports, access roads and bridges, refineries and other structures of high importance and identify the potential impact of “sinking” land and “rising sea” on them. The inundation shapefiles then could be used in creating other shapefiles identifying the impacted infrastructure because of various projected (forecasted) inundation. In this specific study transportation infrastructure was chosen based on ease of availability of spatial data. The datasets were generated by interpreting, analyzing, amending, and integrating data from numerous federal agencies.

5.1 Data sources

The source data was gathered from the four federal agencies - National Geodetic Survey (NGS), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and United States Census Bureau (USCB) as shown in Figure 1 with red ovals. The data from all four agencies was collected and projected from their sourced coordinate systems to NAD 1983 State Plane Louisiana South. The data processing and various steps taken outline an approach that could be adopted for similar projects in future.

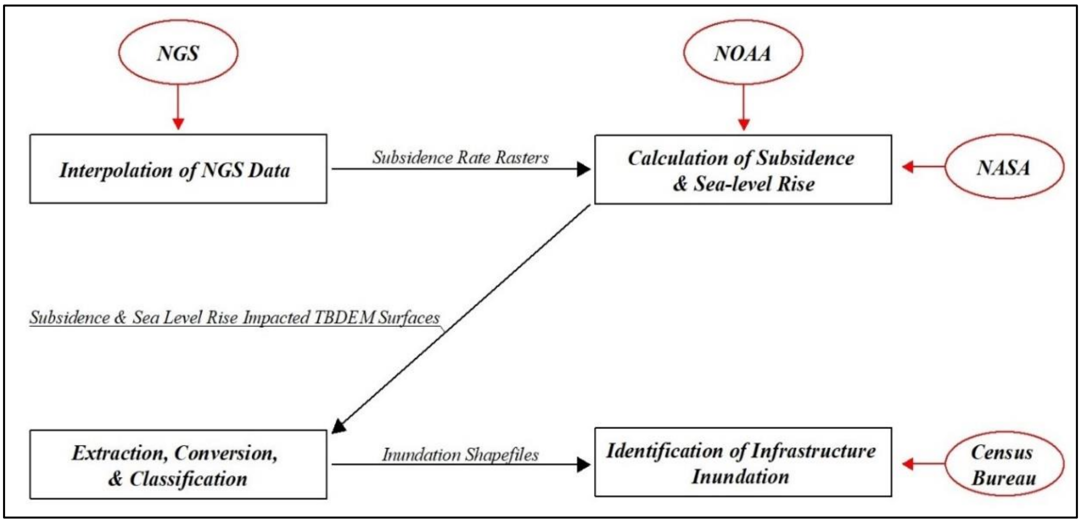

Figure 1. The four stages of the project.

5.2 Methodology

The overall approach is presented in Figure 1. The four main stages of the project are listed below and specific steps taken in each of corresponding of stage are provided in Figures 2A through 2C and 3.

1) Interpolation of NGS data
2) Calculation of subsidence and sea level rise
3) Extraction and conversion
4) Delineation of inundated land

First, the data from NGS was processed and interpolated to get subsidence rate rasters data from the first stage of the project. This raster data was used with NOAA and NASA data to calculate future land subsidence and sea-levels in the second stage. The result of the second stage produced a topobathymetric digital elevation model (TBDEM) that was influenced by the combined effect of land subsidence and sea level rise. In stage three as shown in Figure 1, more steps were taken to extract, convert and classify GIS data to make it ready to be used for the identification of infrastructure located in inundated coastal region in fourth and final stage of the project.

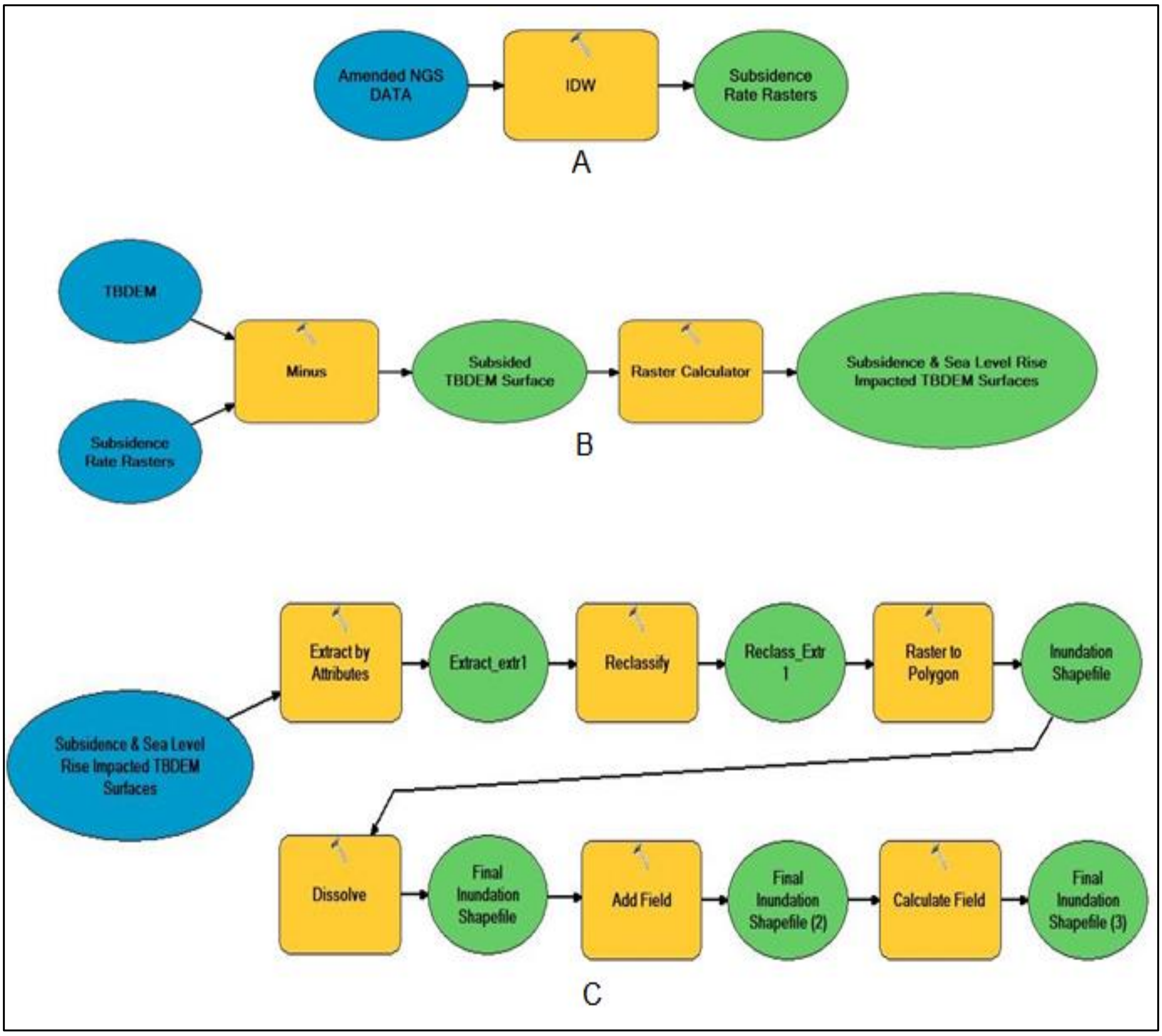

Figure 2. The specific steps taken in at the first three stages of the project A) interpolation of NGS data; B) calculation of subsidence and sea level rise; C) extraction and conversion.

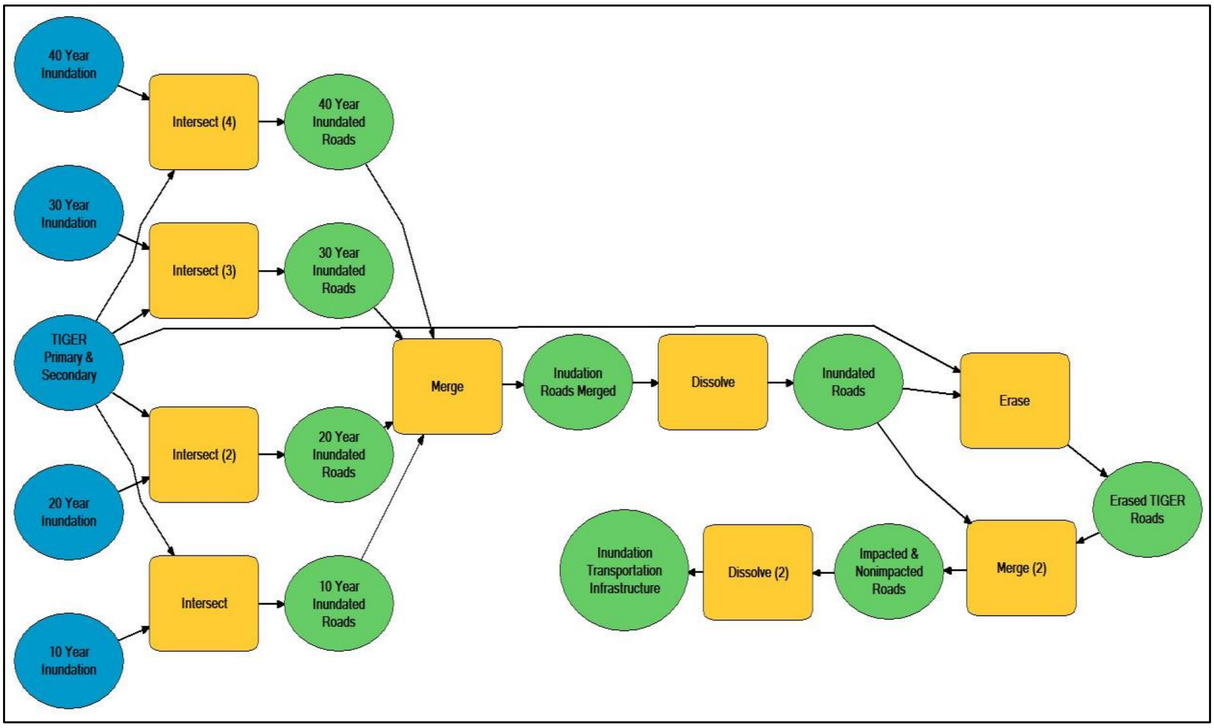

Figure 3. The fourth and the final stage of the project - delineation of inundated land.

6.0 Conclusion

The problem-based learning activity resulted in a greater understanding of the theory for the participating student. Both educator and student were able to produce meaningful data over the period of this engagement. The sample results are shown in Figures 4 and 5. The partnership prepared the student for real-life projects even before the student graduated. As student immersed himself deeper into this area, he gained a better understanding of the concept and higher level of confidence. He started taking on similar challenges in coordination with author. It resulted in joint productions originating from this partnership [9] – [15]. Many of the results were adopted by one state agency. The partnership was mutually beneficial. The initial interaction about the problem and different ways to solve it using previously gained knowledge and skills, motivated student to pursue the project. The student gained new knowledge and skills during the problem solving, which he used to secure a student researcher job that paid pretty well, as good as graduate students on author's research projects. There was a tremendous level of improvement in student's technical writing skills. The project based learning presented in this paper, helped student secure a fulltime job with the sponsoring agency that funded author's couple of research projects.

A more personalized problem-based learning could result in a higher level of student engagement like it did in this study. However, one needs to note this kind of learning would require a motivated student and equally motivated educator. The author initially needed a student with required set of knowledge and skills, which usually are not seen in a typical undergraduate student. This motivated author to invest time and effort in a student who was equally willing to learn. The pedagogical aspects are the ones that were adopted by the author during this experience. This method of individual mentoring could be modified to provide similar level of mentoring to multiple students for a special course and greater student engagement in the area of ocean and marine engineering.

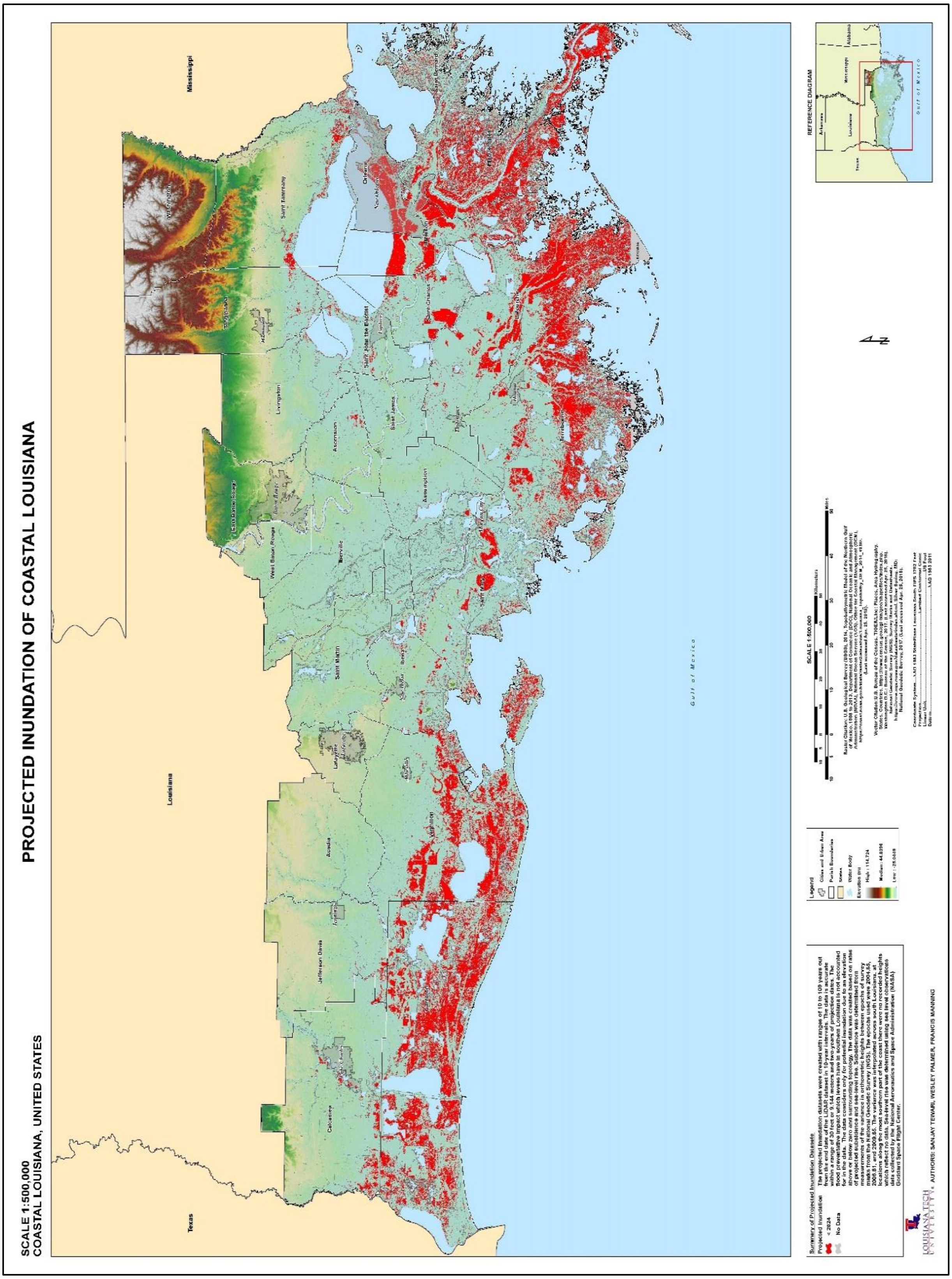

Figure 4. A sample map of 10-year projected inundation of coastal Louisiana.

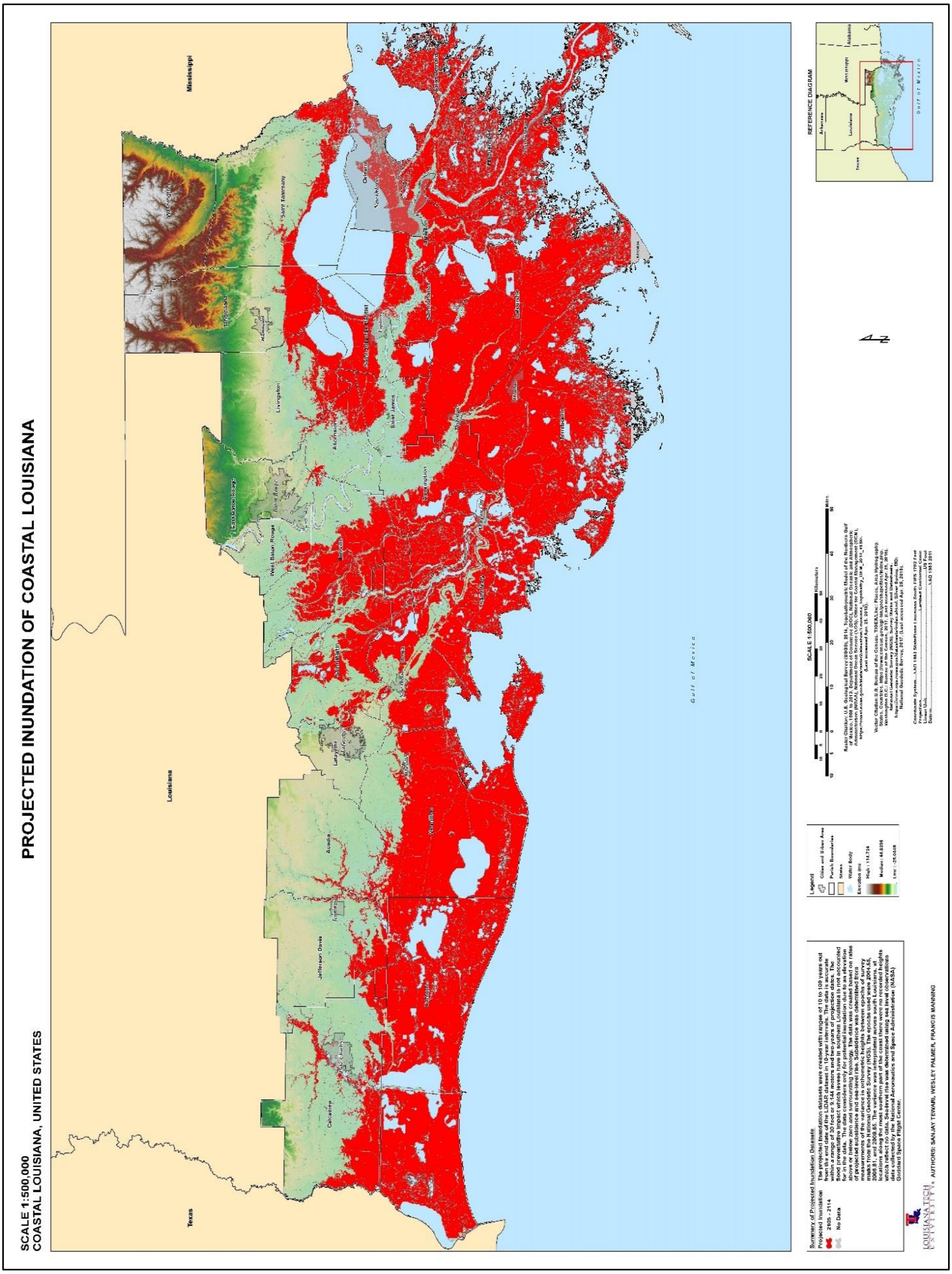

Figure 5. A sample map of 100-year projected inundation of coastal Louisiana.

References

1. R. M. Felder and L. K. Silverman, "Learning and Teaching Styles in Engineering Education," Engineering Education, vol. 78, p. 8, 1988. Available at https://www.engr.ncsu.edu/wp-content/uploads/drive/1QP6kBI1iQmpQbTXL-08HSl0PwJ5BYnZW/1988-LS-plus-note.pdf
2. R. M. Felder and E. R. Henriques, "Learning and Teaching Styles In Foreign and Second Language Education," Foreign Language Annals, vol. 28, pp. 21-31, 1995. Available at https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1944-9720.1995.tb00767.x
3. R. M. Felder, G. N. Felder, and E. J. Dietz, "The Effects of Personality Type on Engineering Student Performance and Attitudes," Journal of Engineering Education, vol. 91, pp. 3-17, 2002. Available at https://onlinelibrary.wiley.com/doi/abs/10.1002/j.2168-9830.2002.tb00667.x
4. R. M. Felder and R. Brent, "Understanding Student Differences," Journal of Engineering Education, vol. 94, pp. 57-72, 2005. Available at https://onlinelibrary.wiley.com/doi/abs/10.1002/j.2168-9830.2005.tb00829.x
5. R. M. Felder and J. E. Spurlin, "Applications , Reliability and Validity of the Index of Learning Styles," International Journal of Engineering Education, vol. 21, p. 10, 2005. Available at https://www.engr.ncsu.edu/wp-content/uploads/drive/1ZbL_vMB7JmHGABSgr-xCCP2z-xiS_bBp/2005-ILS_Validation(IJEE).pdf
6. S. Tewari, M. A. Ahmed, and C. M. Tummala, "Generating Interest Among Undergraduates Toward Research in Environmental Engineering by Incorporating Novel Desalination Technology-based Hands-on Laboratory Assignments," presented at the 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, 2018. Available at https://peer.asee.org/30558
7. S. Tewari, "Environmental Engineering Laboratory Development to Promote Active and Hands-On Learning," in Second Mid Years Engineering Experience Conference Slump to Jump!, College Station, TX, 2016. Available at http://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=1950&context=civarc_enveng_facwork
8. K. P. Cross, "Our Changing Students and Their Impact on Colleges: Prospects for a True Learning Society," The Phi Delta Kappan, vol. 61, p. 4, 1980.
9. S. Tewari and F. Manning, "Identifying Corrosion Zones in Coastal Regions for Metal Pipes - A GIS Approach," in Pipelines 2017: Planning and Design, Phoenix, AZ, 2017, pp. 618-625. https://doi.org/10.1061/9780784480885.057
10. S. Tewari, "Corrosion Map for Metal Pipes in Coastal Louisiana," Louisiana Transportation Research Center, 2017. Available at http://www.ltrc.lsu.edu/pdf/2017/FR_585.pdf
11. S. Tewari and F. Manning, "Spatial Delineation of Corrosion Zones for Metal Culverts Based on Coastal Louisiana Soil Characteristics," in 97th Annual Meeting of Transportation Research Board, Washington D.C., 2018. Available at https://trid.trb.org/view/1495804
12. S. Tewari and W. Palmer, "Identification of Transportation Infrastructure at Risk due to Sea Level Rise and Subsidence of Land in Coastal Louisiana," Louisiana Transportation Research Center and Louisiana Department of Transportation and Development, 2018. Available at https://www.ltrc.lsu.edu/pdf/2019/18_5TIRE.pdf

13. S. Tewari, F. Manning, and W. Palmer, "Identification of Critical Transportation Infrastructure At-Risk In Coastal SPTC Region," Southern Plains Transportation Center, 2018.
14. S. Tewari, F. Manning, and W. Palmer, "Sea Level Rise and Land Subsidence in Coastal Louisiana: Forecasting, Mapping and Identification of At-risk Transportation Infrastructure," in 98th Annual Meeting of Transportation Research Board, Washington D.C., 2019. Available at http://amonline.trb.org/68387-trb-1.4353651/t0010-1.4369516/1426-1.4369687/19-04682-1.4361933/19-04682-1.4369690?qr=1
15. S. Tewari, F. Manning, and W. Palmer, "Application of GIS/Geomatics to Areas Affected by Subsiding Land and Rising Sea: Simulation of Risks and Identification of At-risk Infrastructure," in 2019 Pipelines Conference, Nashville, TN, 2019.