**APPENDIX D**

**SAES-422**

**Format for Multistate Research Activity**

**Accomplishments Report**

***Note:*** *This report is submitted each year of an activity’s duration and is due 60 calendar days following the annual meeting. The SAES-422 is submitted electronically by AAs into NIMSS. Annual Reports for MRF projects are available to NIFA through NIMSS.*

**Project/Activity Number: S1089**

**Project/Activity Title: Quantification of best management practice effectiveness for water quality protection at the watershed scale**

**Period Covered:** **2022-2023**

**Date of This Report: 11/07/2023**

**Annual Meeting Date(s):**  **09/12/2022 - 09/13/2023**

**NIMSS Project page:** [**https://www.nimss.org/projects/18705**](https://www.nimss.org/projects/18705)

**1. Annual Meeting**

* Participants:

In person attendees (11):

* Fouad Jaber - Texas A&M
* Rafael Muñoz-Carpena - University of Florida
* Francois Birgand - NCSU
* Jasmeet Lamba - Auburn University
* Latif Kalin - Auburn University
* Aleksey Sheshukov - Kansas State University
* Emine Fidan - University of Tennessee
* Eban Bean - University of Florida
* Young Gu Her - University of Florida
* Sanjiv Kumar - Auburn University
* Rakesh Kumar - Auburn University

Virtual Attendees (13):

* Soni Pradhanang - University of Rhode Island
* Adel Shirmohammadi - University of Maryland
* Bill Ford - University of Kentucky
* Zach Easton - Virginia Tech
* Elizabeth Boyer - Penn State University
* Arun Bawa - Texas A&M
* Raghavan Srinivasan - Texas A&M
* Natalie Nelson - North Carolina State University
* Sara McMillan - Iowa State University
* Prem Parajuli- Mississippi State University
* Rabin Bhattarai- University of Illinios-UC
* Mary Savin - University of Arkansas
* Josef Gorres - University of Vermont
* Summary of minutes of annual meeting:

The annual meeting was held in the College of Forestry, Wildlife and Environment (CFWE) at Auburn University in Auburn, AL on September 12-13, 2023 with participation of 13 members on Zoom and 11 members in-person. The meeting agenda included state reports of accomplishments and active projects, discussions on collaborative activities, special collection of journal papers on BMP monitoring and management, a proposal for the next cycle of this Hatch project, and potential submission of a proposal for Experiment Station Section Award for Excellence in Multistate Research. The meeting featured a workshop on the impact reporting provided by the Multistate Research Fund Impacts Program. Prior to the meeting, the members submitted their state reports. A brief overview of the activities during the meeting is below:

* The meeting started with Dr. Paul Patterson, Dean of the College of Agriculture and Director of the Ag Experimental Station of Auburn University, welcoming the participants to Auburn and presenting an overview of college mission and activities. Then, Dr. Mary Savin, a NIFA advisor, and Dr. Fouad Jaber, S1089 chair, provided recaps of USDA-NIFA’s Hatch program and a history of prior S1089 projects, respectively. A recap of the annual S1089 meeting in Houston in 2022 completed a morning part of the meeting.
* After the break, S1089 members (in person and virtual) reported on their state activities and accomplishments, including active projects, funded proposals, and students and publications. A discussion on multistate collaborative efforts followed the individual reporting.
* **Impact writing workshop**. The afternoon of Day 1 was dedicated to the impact writing workshop virtually led by Sara Delheimer ([sara.delheimer@colostate.edu](mailto:sara.delheimer@colostate.edu)), a program coordinator and impact writer for the Multistate Research Fund Impacts Program ([www.mrfimpacts.org](http://www.mrfimpacts.org)). Ms. Delheimer shared the best practices on how to better articulate the impact of multistate projects and activities, to demonstrate the value to stakeholders, funding agencies, and the general public. Examples of different impact statements from Hatch Multistate project reports were presented and discussed.
* Dr. Kalin and a director of the Alabama Water Center led a field trip of the LID facility in Auburn. This concluded Day 1.
* **Journal special collection.** Day 2 was fully dedicated to the discussion on journal special collection started in 2021.
  + Journal of Environmental Management (Elsevier, IF=8.7) was selected
  + Fouad updated on communication with the journal and informed of the need to submit a proposal for approval
  + 16 initial contributions were identified from the project members on new insights and gaps in BMP research at field and watershed scales including monitoring, modeling and interdisciplinary and translational studies, specifically the following topics were of particular interest:
    - Advances in BMP design
    - Advances in BMP monitoring
    - Quantification of BMP ecosystem services
    - Achieving Nutrient and Sediment Reduction Goals Through Watershed Management
    - Limitations and uncertainties in predicting mitigation of runoff contaminants with BMPs
    - Alternative water resources in the context of climate change
    - Legacy nutrients and sediments impacting the efficiency of BMP performance
    - Using advanced techniques in identifying and targeting BMPs in urban, agricultural and forested watersheds.
  + Proposed guest editors are: Fouad Jaber (Texas), Latif Kalin (Alabama), Soni Pradhanang (Rhode Island), Aleksey Sheshukov (Kansas).
* **Hatch project award**. S1089 members expressed their interest in exploring nomination for the Experiment Station Section Award for Excellence in Multistate Research. Project officers were tasked to discuss the conditions of the award and prepare a draft of nomination documents.
* **Next project cycle proposal**. Current S1089 project ends in September 2025. To avoid a gap in project continuation and funding, a new proposal should be prepared shortly after the end of the 2023-24 fiscal year. Project officers and a leadership group will work on drafting the proposal in 2024.
* **Next annual meeting location**: Kansas City, KS
  + Project officers will communicate with NIFA for the meeting location and potential participation. As an alternative, Dr. Sheshukov will organize a meeting at the K-State's campus in Olathe, KS.
* **Annual S1089 project report**: Need to be submitted within 60 days after the annual meeting. Project officers will compile individual state submissions and summarize the accomplishments.
* **Election**: Dr. Emine Fidan was nominated by Dr. Munoz-Carpena and elected project Secretary for 2023-24. This concluded Day 2. Meeting was adjourned.

Elected officers (2023-2024):

* Secretary: Emine Fidan (U Tennessee)
* Vice Chair: Latif Kalin (Auburn U)
* Chair: Aleksey Sheshukov (KSU)

Past Chairs:

* Soni Pradhanang (2020-2021)
* Rafa Munoz-Carpena (2021-2022)
* Fouad Jaber (2022-2023)

**2. Accomplishments:**

The main focus of this project is to improve the abilities to better understand and predict fate and transport of pollutants and evaluate the effectiveness of best management practices (BMPs) on critical landscapes at the watershed scale. This includes hillslope soil health, water quality of streams and waterbodies, environmental benefits of mitigation practices and cost effectiveness of BMPs. The objectives will be met through the following activities: monitoring at sub-watershed scales, model development and applications at various spatial and temporal scales, and analyzing uncertainty in both monitoring and modeling efforts.

Below are a few examples to the accomplishments from various projects:

* Rainfall simulation experiments were conducted to determine the influence of manure application on pollutant leaching in pastures. Results show that loss of contaminants can be significant in leachate, and topography plays a critical role. Therefore, care and good planning (e.g. timing) is needed before applications.
* The comparison of pore characteristics as a function of treatments showed that soil columns under cover crop treatment had comparatively higher values of porosity and pore number density for the top 100 mm of soil. This is another evidence to the benefits of cover crops.
* A new cell-averaged numerical model is being developed for subsurface vegetated treatment wetlands. The use for treatment wetlands as BMPs to treat both NPS and point source pollutants has seen increase. Tools like these can better help designing such wetlands and understanding flow and nutrient transport.
* A new methodology that combines geospatial and machine learning approaches has been developed to identify gully locations. The developed algorithm will help with the gully detection efforts in larger areas and can be useful for targeting implementation of BMPs.
* Dr. Muñoz-Carpena’s team at UF quantified the effect of vegetative filter strips (VFS) for mitigation of agrochemical pollutants at the field and landscape levels in a variety of agroecological scenarios in the USA and EU using the VFSMOD model they developed. New work was started to quantify the pesticide runoff mitigation efficiency of “spot-applications” in cereal fields using the latest precision/smart agriculture technologies. The work is groundbreaking because up to now there is no method to quantify expected reductions in pesticide runoff off the field compared to typical broadcasting applications.

**Short-term Outcomes:**

Project activities from 2022-2023 are summarized in the following state reports:

Texas A&M (F. Jaber)

Texas A&M AgriLife (AgriLife) program consisted of projects to enhance SWAT modeling both locally and globally and research in nature-based solutions for water volume and quality solutions. AgriLife worked on a national SWAT hydrological and water quality calibration at HUC12 subbasin scale (with USEPA). In addition, a project to enhance modeling of ungaged watersheds using machine learning (ML) techniques is currently underway. Also, a project to develop a 10 km x 1- km gridded global SWAT model is being developed with the Nature Conservancy (TNC).

AgriLife also worked on quantifying the impact of nature-based solutions on flooding and water quality. The Transportation Stormwater Infrastructure project funded by the Texas Water Development Board investigates the impact of Nature-based solutions integrated with future development on flooding in the DFW metroplex. The project involves modeling and development of educational material.

University of Florida (R. Muñoz-Carpena, Y. Her, E. Bean)

Research at the University of Florida has focused on water quality dynamics across different landscapes. In particular, these projects advanced our understanding of the dynamic relationship between the internal hydrodynamics and water quality of a shallow water body (i.e., Lake Okeechobee) and the effectiveness of crop rotation between sugarcane and flooded rice in the Everglades Agricultural Areas. In addition, researchers also evaluated the impacts of sea level rise and weather pattern change on groundwater level and saltwater intrusion in Southeast Florida, the effect of vegetative filter strips for mitigation of agrochemical pollutants at the field and landscape levels, and the impacts of agricultural development of small holders in Africa (Laikipia, Kenya) and adoption of BMP (reduced tillage, soil management) to assess the distant ecological degradation of the dry African savanna introduced by these developments.

Auburn University (L. Kalin, J. Lamba, S. Kumar)

Researchers are Auburn University have been involved in several projects to enhance water quality research. Research focuses are to quantify nutrient losses from fields fertilized with animal manure, examine soil macropore characteristics in cover cropping systems, develop effective adaptation strategies to enhance the resilience of farmers under changing climate, forecast soil moisture through multi-source data integration, develop a cell-averaged numerical model for one-dimensional subsurface flow in a sloping wetland bed for treatment wetlands, and model wetland hydrology and carbon flux modeling in natural wetlands to better understand their carbon sequestration potential.

North Carolina State University (F. Birgand, N. Nelson)

The activities spearheaded by Birgand focused on development of new techniques to monitor stormwater flow from culverts (Obj. 1), and the use of advanced monitoring techniques to monitor the fate of nitrate in a salt marsh, to measure Fe and Mn in lakes, and to test the effects of flow rate on volumetric nitrate removal rates in a woodchip bioreactor (Obj. 2). For the first project, the team used images and videos taken using trail cameras (<$500) to measure water stage in perched culverts. We have used a combination of machine vision and machine learning techniques to tackle the problem. Machine learning techniques such as fast R-CNN (Fast Region-Based Convolutional Neural Network) have provided a wonderful solution to insurmountable culvert detection problems in low light situations. In the second project, the research team tested whether or not increased flow rate through a porous medium would increase volumetric nitrate removal rates from a woodchip bioreactor.

The research spearheaded by Nelson focused on water quality dynamics in coastal settings. The first project developed a framework for nowcasting fecal contamination in coastal waters using *in situ* sampling and machine learning modeling. The second project reconstructed historical bloom exports from reservoirs near Lake Okeechobee with Sentinel-3 OLCI imagery to evaluate bloom locations in relation to water control structures and discharge patterns.

University of Tennessee (E. Fidan, D. Yoder)

One thrust in this time period was focused on *S1089 Objective 1 Develop tools that utilize both monitoring and modeling to better inform targeted BMP implementation*. This examined soil health as a measure of the long-term success of BMP implementation, with an emphasis on soil health measurement and quantification. Findings included that a weighted soil health provided a more robust indication of soil health, and that soil health does serve as a useful measure of long-term BMP implementation. As second thrust related to *S1089 Objective 2 Advance water quantity and quality models for mixed-watershed use* included continued development of the RUSLE2/Ephgee whole-field erosion model, combining hillslope and ephemeral gully erosion. Additional work addressing Objective 2 included the development of a pluvial flood model for agricultural landscapes. Predictive flood maps were developed for North Carolina after Hurricane Matthew (2016). In addition, a Bayesian flood water quality model was built to understand drivers and watershed characteristics of flood water contamination after Hurricane Florence (2018). Findings show high presence of pathogenic bacteria Arcobacter in floodwaters. Model results indicate that rainfall is a major driver, with overtopped WWTPs and nearby agricultural operations being potential sources of contaminants. A third thrust related to *S1089 Objective 3 Test advanced / new monitoring techniques to detect water quality issues* compared classical plot sediment delivery monitoring as “truth”, comparing that to high-resolution ground-based LIDAR to determine if the latter can accurately measure soil loss through da decrease in the soil surface elevation. This study found that even over three years of erosion, LIDAR could accurately see areas of concentrated erosion, but could not see normal sheet and rill hillslope erosion.

University of Rhode Island (S. Pradhanang)

Research at the University of Rhode Island has focused on agricultural water uses and allocation through integrated modeling (SWAT-MODFLOW-WMOST), methane in groundwater, urban stormwater monitoring, saltwater intrusion and bedrock mapping in the coastal areas, and floating wetlands treatment systems. Specifically, water availability during low flow conditions for Chipuxet basin is done using coupled SWAT and MODFLOW models. Further the model is tied to the WMOST water allocation and optimization model to develop water use scenarios. The research project to study methane and greenhouse gasses in marshes and groundwater aims at understanding whether deep groundwater functions as storage or sink of potent greenhouse gasses. Various stormwater basins within RI Roger Williams Park are monitored to study various pollutants including algae in water. The NASA Space Grant and USGS supported State map research focuses on mapping the surface geology statewide and focuses on specific areas at a smaller scale for mapping additional layers. RIGS, with partners in the state, plans to develop a hydrogeologic model at the watershed scale to inform statewide planning for water resources, flood preparation and response, and drought monitoring. Floating wetland treatment studies were conducted for lakes in Nepal, India, and Bangladesh as a part of Asia Pacific Network Research grant.

Kansas State University (A. Sheshukov)

Major activities in 2023 were centered on development of various computer models and data collection at watershed, hillslope, and reservoir scales. Specifically:

- Ephemeral gully management and detection: We used geospatial and machine learning approaches to identify gully locations on agricultural hillslopes of central Kansas. We processed LiDAR elevation datasets and applied a combination of terrain-index and machine learning algorithms for gully detection. We used additional Hatch funding to develop a new methodology on gully detection from historical images/Google Earth imagery and successfully tested it Turkey creek watershed north of the city of Wichita. The developed algorithm will help with the gully detection efforts in a larger area and can be useful for targeting implementation of BMPs.

- Watershed management. We completed a SWAT model development for the Prairie Band Pottawatomie Nation tribal area within the Soldier Creek watershed north of Topeka, KS. The model accounts for specific cropland and rangeland practices that are utilized within the tribal land and obtained from local stakeholders with close partnership with KDHE and tribal community. Based on the results, a plan for BMP implementation in the watershed was included in a watershed management plan submitted to EPA.

- Blue green algae. We continued data collection from a multi sensor stationary buoy in Marion Reservoir in Kansas for recording various in-situ water properties and meteorological variables. The buoy is instrumented with in-situ sensors for near continuous measurements of water temperature, specific conductance, dissolved oxygen, pH, dissolved organic matter, turbidity, light penetration and chlorophyll and phycocyanin fluorescence. Forecasting of potential harmful algal blooms and recommendation for lake management is a goal of this study. PD Sheshukov coordinated with KSRE extension specialists a trial study on the effectiveness of rapid blue green algae tests for the use by extension agents and local producers and homeowners.

- Cotton production management. We studied the benefits (economic and environmental) of cotton production in western Kansas by analyzing the data on three cotton fields collected from above and below ground sensors of the flux towers. We completed the plot study (2021-2023) in a center-pivot field in SWREC on the efficiency and water use of different irrigation technologies (LESA, LEPA, MDI). We developed water-productivity functions and analyzed specific crop coefficient functions to better reflect thermo-limited conditions of southern Kansas.

University of Maryland (A. Shirmohammadi)

Monitoring and Modeling based on Long-Term Monitoring Data: Warner Creek Watershed in the Monocracy River Basin: Using paired watershed and upstream-downstream monitoring design, we collected 11 years (2001-2012) of stream flow and water quality constituents (TSS, NH4, NO3-, TN, Ortho-P and TP) in an 850-acre watershed with three Dairy operators located in Frederick County, Maryland. Results indicated that sub-watershed B with about 270 milking cows, with no slurry storage facility, with loafing ground located at the slope at the top of the sub-watershed, and with no riparian or grass filter around the stream had the highest level of pollution. Results also indicated that climate variability had a great impact on the flow and pollutant discharge from the watershed. Using the monitored data, we calibrated and validated a SWAT model and then we developed a Diagnostic Decision Support Systems (DDSS) to capture the most critical areas of the watershed and make sure the appropriate BMPs were implemented.

Other research projects include: optimization of urban stormwater management BMPs using combination of SWAT and genetic algorithms; multi-criteria water resources management using SWAT, DSS, and Agent Based Modeling (ABM); decision support tool for economic evaluation of irrigation applications in temperate zones; use of multiple regression and optimization models to assess the effectiveness of BMPs in pollution reduction and likelihood of BMP implementation; and assessment of agricultural land suitability for irrigation with reclaimed water using geospatial multi-criteria decision analysis.

University of Delaware (S. Inamdar)

A primary research goal that University of Delaware researchers focus on is to better understand the concentrations, forms, and fluxes of nitrogen (N) in watersheds and how land use activities and BMPs affect this pollutant. Currently we have three emphasis areas where we are studying the fate and transport of N. These three focus areas are: (1) the effect of milldams and similar barriers on the concentrations, forms, fate and transport of N in stream and riparian zones; (2) the concentrations, fate and transport of N associated with suspended legacy sediment transport in watersheds; and (3) the concentrations and fate of N in restored stream floodplains. We have multiple NSF and USDA AFRI projects addressing these areas of research. USDA Hatch funds were used for installing redox sensors in riparian zones upstream of the milldams. Hatch funds were also used to purchase a Hach spectrophotometer for analysis of dissolved Fe2+ in groundwater samples.

Pennsylvania State University (E. Boyer, J. Duncan)

Research at Penn State has focused on: Coupled hydrological and biogeochemical processes controlling streamflow and water quality; impacts of multiple stressors (e.g., atmospheric deposition, land use, and climate change) on responses of terrestrial and aquatic ecosystems; application of nature-based watershed management techniques to mitigate environmental problems; terrestrial and aquatic linkages, especially focusing on connectivity in riparian zones and dynamic variable source areas.

Outcomes include: Measurements and models identify sources of nutrient pollution, hotspots of nutrient inputs to the landscape and exports to streamflow, informing where mitigation and management efforts should be targeted. Models yield estimates of uncertainty in nutrient loading exports from the landscape to the stream, highlighting areas where additional measurements will help to improve understanding or predictability. Measurements and models have generated understanding, and new hypotheses, about how hydrological and biogeochemical processes combine to control streamflow and water quality. We are using a suite of models, from physically based to data driven, to simulate flow and water quality, and to explore how watersheds may respond to changing environmental conditions.

Oklahoma State University (K. Wagner)

Watershed research at the Oklahoma Water Resources Center focuses on evaluating implementation of novel regenerative agricultural BMPs and virtual fencing. Through small watershed scale monitoring of water quality and quantity, we are working to inform watershed scale modeling and provide insights into processes that determine pollutant fate and transport and the role these novel BMPs play in pollutant reduction. With funding from USDA-NIFA, 12 small watershed sites were monitored this year in Altus, Oklahoma to evaluate the benefits of regenerative agriculture practices in cotton production systems. Preliminary results suggest that total discharge and nutrient concentrations in runoff are reduced in watersheds where cover crops are used. When the cover crop (winter wheat) was actively growing, soil moisture levels were depleted compared to watersheds with no cover crops; however, throughout the remainder of the year, soil moisture levels were similar regardless of whether cover crops were used or not. With funding from OSU’s Thomas E. Berry Professorship, monitoring of runoff from 10 small watersheds at the OSU Cross Timbers Experimental Range continued, helping improve understanding of how natural sources and conventional grazing practices impact grazingland water quality. E. coli numbers were not significantly different among the 10 watersheds with one exception, the most heavily grazed prairie watershed (GP1), which is used for spring calving, had greater numbers. The lack of significance among watersheds is likely due to the grazed sites being rotationally (and lightly) grazed and wildlife contributions. Finally, with funding from EPA and NRCS, 2 paired watersheds were monitored this year to evaluate the water resource benefits of using virtual fencing to improve grazing management.

Iowa State University (S. McMillan)

Research at Iowa State University has been surrounding the quantification of ecosystem services and climate resilience of restored and constructed wetlands in agricultural landscapes. Current work has focused on linking hydroclimatic and watershed variables to nitrate storm dynamics in the Midwest, using annual mass loading curves and storm metrics to characterize nutrient pathways and sources, and identifying the role of conservation at the small watershed scale by leveraging historical data and high temporal resolution monitoring.

Virginia Tech University (Z. Easton, D. Sample, B. Benham)

Work at Virginia Tech University has ranged across landscapes and disciplines.

For objective 1, we are monitoring and evaluating the first large scale spring bioreactor designed to remove legacy N from groundwater as a way to meet TMDL goals. Additional activities include field identification and verification of candidate sites for legacy N treatment and working cooperatively with Virginia DEQ to formalize a feasible, low-cost N crediting protocol to quantify and certify legacy N reductions from bioreactors for TMDL compliance. Additionally, another project began with a 6-yr monitoring effort to characterize runoff, nutrients and sediment discharges from Virginia Utility Scale Solar Sites (USS), assessing existing models and developing new ones to improve effectiveness of BMPs. To add on, we completed and received EPA approval for an implementation planning document that specified the type and number for BMPs needed to address a bacteria impairment TMDL for the Peak Creek Watershed, a tributary to the New River in SW Virginia.

For objective 2, we assessed the impacts of climate change on terrestrial hydrological components and Crop Water Use (CWU). Results show a reduction (13 % and 17 % respectively) in CWU is estimated for corn and soybeans, resulting from increased total precipitation and rising CO2 levels suppressing evapotranspiration. Our results indicate that even in a warmer regime, crop water use decreased due to rising CO2 concentrations from climate change. Additional research addressing objective 2 assessed Environmental Site Design (ESD) guidance and climate change impacts on stream stability, as well as developed TMDLs to address PCB impairments in the Mountain Run watershed and the James River Watershed upstream of Richmond, VA.

For objective 3, we are developing sensors and the associated analytics to predict livestock manure excretion events and distribution based on animal sensor data and in situ environmental sensors. Sensor data are used to initialize a model of critical runoff/nutrient source areas and to optimize the path of an autonomous robot capable of managing deposited manure. Another similar research project developed a partnership with a nonprofit organization to develop and deploy a secure network of sensors on the Rappahannock River (SmartRiver) for monitoring urban stormwater BMP effectiveness.

**3. Impacts:**

In summary, in 2022-23 project members:

* Published 80 research publications
* Received 31 awarded proposals
* Advised 21 PhDs (9 defended), 11 MS, and 14 undergraduate students
* Mentored 4 Postdocs and Visiting Scientists

**Activities:** The technical committee and the officers met virtually every other month to discuss project objectives, project activities, and plans for the annual meeting.

**4. Products:**

*1). Publications:*

1. Larios, K., S. Gerber, R. Muñoz-Carpena, P. Inglett, K.R. Reddy, M. Chimney. 2023. Effects of increasing complexity in biogeochemistry and hydrology on variability of total phosphorus concentration in models of a low flow subtropical wetland. *Ecological Engineering* xxx (xxxx) 107131. [doi:10.1016/j.ecoleng.2023.107131](https://doi.org/10.1016/j.ecoleng.2023.107131).
2. Chen. H., D.S. Carley, R. Muñoz-Carpena, G. Ferruzzi, Y. Yuan, A. Blankinship, T.L. Veith, R. Breckels, G. Fox, Y. Luo, D. Osmond, H.E. Preisendanz, Z. Tang, K. Armbrust, K. Costello, L.L. McConnell, P. Rice, J. Westgate, M. Whiteside. 2023. Incorporating the benefits of vegetative filter strips into risk assessment and risk management of pesticides. *Integr Environ Assess Manag (IEAM)*. [doi:10.1002/ieam.4824](https://doi.org/10.1002/ieam.4824).
3. Muñoz-Carpena, R., A. Carmona-Cabrero, Z. Yu, G.A. Fox, O. Batelaan. 2023. Convergence of mechanistic modeling and artificial intelligence in hydrologic science and engineering. *PLOS Water*. [doi:10.1371/journal.pwat.0000059](https://doi.org/10.1371/journal.pwat.0000059)
4. Shin\*, S., Y. Her, R. Muñoz-Carpena, X. Yu, C. Martinez and A. Singh. 2023. Climate change impacts on water quantity and quality of a watershed-lake system using a spatially integrated modeling framework in the Kissimmee River-Lake Okeechobee system. *J. of Hydrology: Regional Studies*47:101408.  [doi:j.ejrh.2023.101408](https://doi.org/10.1016/j.ejrh.2023.101408)
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7. Zhang\*, Y., R. Bhattarai and R. Muñoz-Carpena. 2023. Effectiveness of vegetative filter strips for sediment control from steep construction landscapes. *Catena* 226:10705. [doi:10.1016/j.catena.2023.107057](https://doi.org/10.1016/j.catena.2023.107057)
8. Morgan\*, S., R. Huffaker, R. Giménez, M.A. Campo-Bescos, R. Muñoz-Carpena, and G. Govers. 2023. Experimental evidence that rill-bed morphology is governed by emergent nonlinear spatial dynamics. *Scientific Reports*-Nature 12:21500.[doi:10.1038/s41598-022-26114-0.](https://www.nature.com/articles/s41598-022-26114-0)
9. Reichenberger S., R. Sur, S. Sittig, S. Multsch, Á. Carmona-Cabrero, J.J. López and R. Muñoz-Carpena. 2023. Dynamic prediction of effective runoff sediment particle size for improved assessment of erosion mitigation efficiency with vegetative filter strips. *Sci. Total Env.*857(3):159572. [doi:10.1016/j.scitotenv.2022.159572](https://doi.org/10.1016/j.scitotenv.2022.159572)
10. Oh\*, W.S., A. Carmona-Cabrero, R. Muñoz-Carpena, R. Muneepeerakul. 2022. On the interplay among multiple factors: effects of factor configuration in a proof-of-concept migration agent-based model. *Journal of Artificial Societies and Social Simulation (JASSS)* 25(2):7. [doi:10.18564/jasss.4793.](https://doi.org/10.18564/jasss.4793)
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13. Dubey, S. K., J. Kim, S. Hwang, Y. Her, and H. Jeong (2023), Variability of precipitation and temperature extreme events in coastal and inland areas of South Korea during 1961-2020, *Sustainability*, 15(16), 12537. <https://doi.org/10.3390/su151612537>
14. Shin, S.\*, Y. Her, and Y. Khare, Evaluation of impacts of climate change on natural and managed wetland basins (2023), Journal of the American Water Resources Association, Published Online. <https://doi.org/10.1111/1752-1688.13140>
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17. Kaur, P\*., J. Lamba, T.R. Way, V. Sandhu, K. Balkcom, A. Sanz-Saez, and Dexter Watts. 2023 Cover crop effects on X-ray computed tomography derived soil pore characteristics. Journal of Soils and Sediments. https://doi.org/10.1007/s11368-023-03596-7
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19. irrigation thresholds. Agricultural Water Management, 286, 108385. https://doi.org/10.1016/j.agwat.2023.108385
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*2) Ph.D. Dissertations:*

1. Lory L. Willard. 2023. [Quantifying the effects of sustainable intensification practices on streamflow and wildlife: A case study in Laikipia, Kenya.](https://abe.ufl.edu/faculty/carpena/files/pdf/research/reports/Willard_L_FinalDissertation.pdf)  Ph.D. dissertation. [Gainesville, Fla.]: University of Florida. (Chair: R. Muñoz–Carpena)
2. Taisha Venort. 2023. [Evaluating sustainable intensification practices in Sub-Saharan Africa: Approaches linking ecosystems services to livelihood capiutals and agricultural decision making.](https://abe.ufl.edu/faculty/carpena/files/pdf/research/reports/Venort_Dissertation_Final_ADP_.pdf)  Ph.D. dissertation. [Gainesville, Fla.]: University of Florida. (Chairs: R. Muñoz–Carpena & C. Palm)
3. Satbyeol Shin. 2023. [Contribution of external loading and internal hydrodynamics to the water quality of Lake Okeechobee under varying climate conditions](https://ufdc.ufl.edu/UFE0059450/00001). Ph.D. dissertation [Gainesville, Fla.]: University of Florida. (Chair: Y. Her)
4. Komlan Koudahe. 2022. Effect of irrigation technology and plant density on cotton growth, yield, yield components, and water use efficiency, MS, Kansas State University.
5. Mechling, R.B. Streamflow variation over 30 years at the Leading Ridge Watershed in the Appalachian Forest of Pennsylvania
6. Natalie Chazal (2023), Past and Future Coastal Water Quality: Trend Testing and Predictive Modeling Using Regulatory Shellfish Sanitation Data, NC State University
7. Emine Fidan (2022), Understanding Hurricane-induced Water Quantity and Quality Dynamics using Machine Learning and Environmental Data Analytics Approaches, NC State University
8. McCarron, B. 2023. Potential applications of amorphous calcium carbonate (acc) in water treatment operations. Masters Thesis submitted to the University of Rhode Island
9. Bailey, G.N. 2022. Challenges in Approaching the Detection Limits for Hillslope Erosion Using Terrestrial Laser Scanning. M.S. Thesis, the University of Tennessee, Knoxville.

*3) Presentations and Posters*

1. Her, Y. G. Invited presenter, “Evaluating the effectiveness of crop rotation between sugarcane and rice in the Everglades Agricultural Area of Florida using integrated monitoring and modeling approaches”. The 2023 Conference of International Society of Paddy and Water Environment Engineering, Busan, South Korea, October 23-25, 2023.
2. Her, Y. G. Invited presenter, “Quantification of pesticide run-off from spot treatment to mitigate exposure of pesticides to surface water”. 11th European Modelling Workshop (EMW11), Montpellier, France, September 25-27, 2023.
3. Her, Y. G. Invited, “Convergence of Mechanistic Modeling and Artificial Intelligence in Hydrologic Science and Engineering”. NRES Distinguished Lecturer Series. International Meeting of the American Society of Agricultural and Biological Engineering, Omaha, Nebraska, June 11, 2023.
4. Her, Y. G. Exploring the potential of hybrid data- and theory-driven hydrological modeling, poster presentation given at 2023 Information Technology and Applications Symposium. June 23 to 25, 2023. Fujisawa, Japan.
5. Her, Y. G. Invited Platform presentation. The effect of alternative synthetic hydrographs when quantifying pesticide mitigation efficiencies with VFSMOD in exposure assessments. SETAC Europe 33rd Annual Meeting, Dublin, Ireland, 4 May, 2023
6. Her, Y. G. Inviter Seminar, "Unintended Effects of the Inter-Basin Water Transfer Project on the Palo Verde National Park Wetlands". OTS 60th Anniversary Conference Series. Organization for Tropical Studies (OTS), San José, Costa Rica, Wednesday, May 31 2023 (virtual presentation)
7. Her, Y. G. Impacts of climate change and sea level rise on southeast Florida’s groundwater resources, poster presentation given at 2023 The Greater Everglades Ecosystem Restoration Conference. April 17 to 20, 2023. Coral Springs, Florida.
8. Willard, L.L., Venort, T., Muñoz-Carpena, R., Palm, C., and Gitonga, J. 2023. Evaluating the effects of conservation tillage on water availability for ecosystems and livestock in Laikipia, Kenya. UF ABE Spring 2023 Poster Symposium (Poster)
9. Venort, T., Willard, L.,Palm, C.A., Muñoz-Carpena, R. and Maltais-Landry,G.- Linking agricultural intensification-extensification decision factors to soil and water related ecosystem services, University of Florida Agricultural and Biological Engineering Graduate Research Symposium, March 2022. (Poster)
10. Willard, L.L., Venort, T., Muñoz-Carpena, R., Palm, C., and Gitonga, J. 2022. Quantifying the effects of sustainable intensification practices on surface water in Laikipia, Kenya. American Society of Agricultural and Biological Engineers Annual International Meeting, Houston, TX, July 2022. (Oral)
11. Venort, T., Palm, C.A., Muñoz-Carpena, R. and Willard, L.L. Linking producers’ decisions to ecosystem services in Laikipia Kenya, Society of Agricultural and Biological Engineers’ Annual International Meeting, Houston, Texas, July 2022. (Oral)
12. Phillippe, A.J., Wagner, K.L., & Reuter, R.R. (2022, December 8). Water Quality Response of Rotational Grazing and Riparian Zone Exclusion Using Virtual Fencing Technology [Conference Presentation]. Oklahoma Governor’s Water Conference, Oklahoma City, OK, United States.
13. Wagner, K. New Strategies for Managing Irrigation Water Depletion. 2023 UCOWR/NIWR Annual Water Resources Conference, Ft. Collins, CO.
14. Gholson, D., K. Wagner, L. Levers, A. Kremen, N. Quintana, S. Bradford. Panel: Addressing Groundwater Depletion across Regions and Aquifers. 2023 UCOWR/NIWR Annual Water Resources Conference. Ft. Collins, CO.
15. Lewis, K., K. Wagner, P. DeLaune, A. Berthold, B. Guerrero. Panel: Overcoming the Challenges of Regenerative Ag Systems in Water-Limited Environments. 2023 UCOWR/NIWR Annual Water Resources Conference. Ft. Collins, CO.
16. Y. Zhou, C.B. Weerasekara, A.Y. Sheshukov (2023) Mapping accuracy of close-range terrestrial digital photogrammetry. ASABE Soil Erosion Research under a Changing Climate Symposium. ASABE Symposium Paper # 028, Aguadilla, Puerto Rico, USA. January 8-13, 2023. https://doi.org/10.13031/soil.23028
17. C. Conoscenti, A.Y. Sheshukov (2023) Regional variability of topographic index and machine learning model applications for prediction of ephemeral gullies. ASABE Soil Erosion Research under a Changing Climate Symposium. ASABE Symposium Paper # 037, Aguadilla, Puerto Rico, USA. January 8-13, 2023. https://doi.org/10.13031/soil.23037
18. Aleksey Sheshukov, Umme Fatema Piu, Komlan Koudahe, Jonathan Aguilar, Dennis Tomsicek, Jingfeng Wang (2022) Evaluating Actual Evapotranspiration Rates and Water Stress of Cotton in Western Kansas. AGU Fall Meeting, Chicago, IL
19. Komlan Koudahe, Jonathan Aguilar, Aleksey Sheshukov (2022) Assessing Cotton Water Requirement using OpenET and Water Balance Models in Western Kansas. Governor’s conference of the future of water in Kansas. Manhattan, KS
20. Abigail Kortokrax, Nathan Nelson, Kraig Roozeboom, Gerard Kluitenberg, Peter Tomlinson, DeAnn Presley, Dan Sweeney, Gary Pierzynski, Aleksey Sheshukov, and Ammar Bhandari (2022) Development and Evaluation of a Component Phosphorus Index for the State of Kansas. Governor’s conference of the future of water in Kansas. Manhattan, KS
21. Kelechi Igwe, Vaishali Sharda, Aleksey Sheshukov, Trevor Hefley. (2022) Modeling the Impacts of Climate Extremes on Crop Evapotranspiration. Governor’s conference of the future of water in Kansas. Manhattan, KS
22. Laura Krueger, Trisha Moore, Aleksey Sheshukov, Lior Shamir, Daniel Flippo, Kavya Kompella. (2022) Investigating Marion Reservoir cyanobacteria harmful algal blooms (HABs) through integrated modeling and data science approaches, Governor’s conference of the future of water in Kansas. Manhattan, KS
23. Kavya Kompella, Lior Shamir, Trisha Moore, Aleksey Sheshukov, Daniel Flippo, Laura Krueger (2022) Predictive analytics and data driven approach to algae bloom prediction. Governor’s conference of the future of water in Kansas. Manhattan, KS
24. Kyle Kohman, Lior Shamir, Aleksey Sheshukov (2023) Automatic Gully Mapping Using Generative Adversarial Network. K-State AI Symposium, Manhattan, KS
25. Laura Krueger, Trisha Moore, Aleksey Sheshukov, Lior Shamir, Daniel Flippo, Kavya Kompella (2023) Investigating Marion Reservoir Cyanobacteria Harmful Algal Blooms (HABs) through integrated modeling and data science approaches. ASABE AIM, Omaha, NE
26. KEB Moore, RA Kowalczyk, and EW Boyer. Status and Trends of Water Quality in the New York City Water Supply Watersheds. New York City Watershed Science & Technical Conference, September 2023.
27. (Invited). Boyer EW, DM McKnight, and D Levia. Sources and Transport of Organic Matter in America’s Surface Waters Under Changing Environmental Conditions. American Chemical Society, San Francisco, CA, August 2023.
28. Song, Y., Chaemchuen, P., Rahmani, F., Zhi, W., Li, L., Liu, X., Boyer, E., Bindas, T., Lawson, K., and Shen, C.: Deep learning insights into suspended sediment concentrations across the conterminous United States: Strengths and limitations, EGU General Assembly 2023, Vienna, Austria, April 2023.
29. Zhi W, C Shen, EW Boyer, G Shenk, X Liu, L Li. A Continental-scale Deep Learning Model for Total Phosphorus Reveals Progress Toward Water Quality Goals over the Past 40 Years in the United States. American Geophysical Union, Fall Meeting, Dec. 2022.
30. Byanju, A., Basnet, C., Pradhananga, D., Pradhanang, S.M., Joshi, A., Pradhanang, S., Aryal, D. and Nepal, P., 2022, December. Microcosm Study of Floating Treatment Wetlands System (FTWS) to Remediate Polluted Water of Kathmandu Valley, Nepal. In AGU Fall Meeting Abstracts (Vol. 2022, pp. H22A-06).
31. Panthi, J., Boving, T., Pradhanang, S.M., Ismail, M.Y., McCarron, B. and Motta, S., 2022, December. Evaluation of submarine groundwater discharge fluxes with time-lapse geophysical measurements. In AGU Fall Meeting Abstracts (Vol. 2022, pp. H35J-1252).
32. Fidan, E.N. R. Emanuel, B.Reich, A. Harris, N. Nelson (2023) Capturing the drivers of nutrient trends in flood-impacted surface waters using statistical learning. American Society of Agricultural and Biological Engineers Annual International Meeting. Omaha, Nebraska. Oral.
33. Fidan, E.N. R. Emanuel, B.Reich, A. Harris, N. Nelson (2023) Quantifying drivers of water quality trends in floodwaters using statistical learning methods. American Ecological Engineers Society. Tampa, Florida. Oral.
34. Fidan, E.N., R. Emanuel, B.Reich, A. Harris, N. Nelson (2023) Patterns and drivers of nutrient trends in flood-impacted surface waters: Insights from Bayesian modeling approaches. European Geophysical Union. Vienna, Austria. Lightening.
35. Fidan, E.N., N. Nelson, R. Emanuel, B.Reich, A. Harris (2023) Patterns and Drivers of Nutrient Trends in Flood-Impacted Surface Waters. Tennessee American Water Resources Association: Water Resources Symposium. Burns, Tennessee. Oral.
36. Jaber F. H. and Heidari B. 2023. A novel approach to integrate green stormwater infrastructure in urban planning for flood reduction and resiliency. American Ecological Engineering Society Meeting June 2023, Tampa, FL.
37. Jaber F. H. 2023. Developing and implementing a rainwater harvesting extension program for agricultural applications in Algeria. ASABE Annual Meeting, Omaha, NE July 2023.
38. Heidari, B., Prideaux, V., Jack, K. Jaber F. H. 2023. A planning framework to mitigate localized urban stormwater inlet flooding using distributed Green Stormwater Infrastructure at an urban scale: Case study of Dallas, Texas. 2023 Low Impact Development Conference, ASCE, Oklahoma City, OK.
39. Jaber F. H. and Reazin, D. Incorporating Green Stormwater Infrastructure into Hazard Mitigation Planning: Denton County, TX Case Study. 2023 Low Impact Development Conference, ASCE, Oklahoma City, OK.

*4) Students Mentored:*

In total:

* 21 PhDs
* 11 M.S.
* 14 undergraduates
* 3 visiting Scientists
* 1 Postdoctoral Associate

3 Ph.D. students working on these activities have been advised by Dr. Muñoz Carpena during this reported period, 2 of them graduated in Summer 2023. Four Ph.D.s, 2 M.S students, 5 undergraduate students. 1 Ph.D. student has been advised by Dr. Her during the reporting period. Christopher Whitely, MS, Natural Resources, May 2023 (Auburn). Jack Edwards, MS, Environmental Science, Oklahoma State University. Austin Phillippe, PhD, Natural Resource Ecology and Management, Oklahoma State University. Kansas State: Jeeban Panthi, Postdoctoral Associate, BAE, Grazia Azzara, Visiting Research Scholar, BAE, Laura Krueger, PhD student, BAE, Aditya Jha, PhD student, BAE, Komlan Koudahe, MS Student, BAE (Graduated 2022), Corben Monzon, MS student, BAE, Annet Biju, MS Student, Computer Science, Sean Hackenberg, REU student, Computer Science, Kyle Kohman, REU student, Computer Science.1 PhD (Alexandra Orr, co-advised by Boyer/Duncan) Penn State. Qianyu Hang, Ph.D. student. NC State: Mohammad Nooshzadi, M.S. student, Nora Sauers, undergraduate student, Emine Fidan, Ph.D. student, Megan Carr, Ph.D. student, Hector Fajardo, Ph.D. student, Julia Harrison, Ph.D. student, Caroline Woods, undergraduate student. Four Ph.D.s, 2 M.S students, 5 undergraduate students (Rhode Island). Savannah Jobkar, MS Student to Fidan, Evelyn Hedrick, Undergraduate Assistant to Fidan, Hannah Thomas-Fletcher, Undergraduate Assistant to Fidan. Michelle Wood-Ramirez MS (Jaber). 2 visiting Scientists from Osmania University (India) Jaber.

*5) Collaborative Proposals Awarded:*

1. Co-PIs from NC State (Birgand) and UF (Muñoz-Carpena) developed 2 proposals from conversations at the Hatch Project meetings and follow up meetings during the last reporting period:
2. USDA-NIFA AFRI. Taking the pulse of near-stream saturated buffers. 08/15/2024 08/14/2027. $649,995.90 (Pending)
3. Ochsner, T., P. Weckler, K. Wagner. Oklahoma Center for Hydrological Integrated Monitoring, Modeling, and Mitigation. Amount: $311,243. Sponsor: NOAA, 9/1/2023-8/31/2025.
4. Wagner, K. Oklahoma Initiative to address COVID-19 Health Disparities. Amount: $170,000. Sponsors: CDC / OK State Dept of Health, 6/1/2023-5/31/2024.
5. Wagner, K., A. Mansaray, R. Srinivasan. Development of OK-HAWQS – Year 3. Amount: $139,113. Sponsor: Oklahoma Conservation Commission, 1/1/2023-12/31/2023.
6. Wagner, K. Dam Analysis Modernization of Tools, Applications, Guidance, and Standardization (DAM-TAGS) Project – Year 3. Amount: $687,216. Sponsor: USDA-ARS Cooperative Agreement, 6/10/2022-6/9/2023.
7. Wagner, K. Dam Analysis Modernization of Tools, Applications, Guidance, and Standardization (DAM-TAGS) Project – Year 2. Amount: $492,585. Sponsor: USDA-ARS Cooperative Agreement, 6/10/2022-6/9/2023.
8. Wagner, K., J. Gonzalez Estrella, J. Vadjunec, A. Apblett, P. Jeyasingh, C. Zou. Oklahoma Water Resources Research Institute Program (USGS Base Funds FY22). Amount: $133,770. Sponsor: USGS, 9/1/2022-8/31/2023.
9. Wagner, K., A. Mansaray, R. Srinivasan. Development of OK-HAWQS – Year 2. Amount: $144,873. Sponsor: Oklahoma Conservation Commission, 10/1/2021-12/31/2022.
10. Developing and assessing innovative ephemeral gully erosion control practices. T Franti, A. Sheshukov, J. Lory, R. Cruse. (2021-2023) USDA-NRCS
11. Valuing Water Quality Improvements in Heartland Reservoirs. R.L. North, A. Ohler, L. McCann, T. Moore, A. Sheshukov. (2022-2025) EPA-STAR
12. Inamdar, S. et al., 2023. Anthropogenic choke points and margins as biogeochemical and pollution hot spots. Gordon Research Conference on Catchment Science, June 18-23, 2023, Andover, NH.
13. Sena, M. et al, 2023. Temporal Patterns of Ammonium Concentrations in Anoxic Riparian Sediments Upstream of Milldams. Gordon Research Conference on Catchment Science, June 18-23, 2023, Andover, NH.
14. Novel techniques to enhance physical and biological nutrient treatment and recovery at rural wastewater facilities. MB Burchell, F Birgand, P Kolar, R Sartor. NC WRRI $119,987
15. Transdisciplinary Program on Agricultural Diffuse Pollution. L Guertault, F Birgand, C Poole, SB Kulesza, TW Gannon, RA Branan, J Baker, S Kellogg, J Gillepsie. USDA-NIFA $660,527
16. Low-Cost Visual Sensing of Stormwater Outlet Flow. F Birgand & S Young. NC DOT. $227,792
17. Future of Aquatic Flows: Exploring Changes in the Freshwater/Saltwater Interface and its Impacts to Aquatic Species. Natalie Nelson. USGS. $255,421.
18. Characterizing fecally-associated bacteria in tidal floodwaters and associated risks to pedestrians. Natalie Nelson, Megan Carr, Angela Harris, Katherine Anarde. NC Sea Grant. $10,000.
19. Cardace, D., Pradhanang, S. M., and Moseman-Valtiera, S., Planetary Methane in Ultramafic Contexts: Searching for Cyclicity in Methane Emissions at a Planetary Analog Site in Northern California, NASA-EPSCoR $735,000 (6/2022-6/2025)
20. Savage, B., Pradhanang, S. M., Boving, T., Mapping Bedrock and Saltwater Intrusion in Rhode Island USGS $117,337 (09/2022-08/2023)
21. Pradhanang, S., Kumar, R, and Rashid T, Floating Treatment Wetland System (FTWS) - Sustainable green technology to remediate polluted surface water bodies in the COVID 19-era , Asia- Pacific Network $78,000 (09/2021-12/2023)
22. Pradhanang, S. M., and Liu, P. Agricultural water use, allocation, and optimization through integrated modeling, USGS, $50,000 (08/2022-10/2023)
23. Fidan, E.N., Gan, H., and Hawkins, S. (2023) Quantifying Agricultural Water Use in Tennessee and Assessing Areas of Potential Water Availability Concern. USGS 104b Grant through Tennessee Water Resources Research Center. $26,000. 9/1/2023 – 8/31/2024.
24. D. Yoder. RUSLE2 Maintenance. USDA-NRCS through CESU agreement with Clemson University. $159,305 from 2022-2027
25. D. Yoder. RUSLE2 Development. USDA-NRCS through CESU agreement with Clemson University. $125,740 from 2022-2025
26. Rowlett Creek Watershed Protection Plan. Texas Commission on Environmental Quality/USEPA 319h funds. $131,984
27. Evaluating BMP Effectiveness for Community Gardens in Dallas-Fort Worth Watersheds. Texas Commission on Environmental Quality/USEPA 319h funds. $267,563.
28. Hydrologic and Hydraulic support to NCTCOG Integrated Watershed Based Planning for Regional Transportation and Stormwater Management in the Upper Trinity River Basin. Texas Water Development Board. $500,000.
29. SCC-CIVIC-PG Track A: Community-Science Partnership to Enhance Stormwater Adaptation under Climate Change. NSF. $50,000.
30. Arlington Urban BMP Implementation. Texas Commission on Environmental Quality/USEPA 319h funds. $360,418.
31. Green Stormwater Infrastructure (GSI) Demonstration Site Development for Greenspace Education in the Galveston Bay Watershed. Texas Commission on Environmental Quality.$82,661.