Promoting Sustainable Agricultural Practices to Reduce Nitrogen and Phosphorus Runoff in Northeastern Missouri

Project Blueprint using the Logical Frameworks approach

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EVPC-321: Leading Change: Project Stewardship for Environmental Transformation

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Contents

1. Annotated Bibliography

Jabbar, F. K., & Grote, K. (2018, November 14). *Statistical assessment of nonpoint source pollution in agricultural watersheds in the Lower Grand River watershed, MO, USA.* In *Environmental Science and Pollution Research*, *26(2), 1487-1606*. https://link.springer.com/article/10.1007/s11356-018-3682-7#Abs1

Jabbar and Grote (2018) investigate the contribution of nonpoint source agricultural pollution to surface water degradation by analyzing nitrate, phosphate, dissolved oxygen, and related water quality indicators through a combination of field sampling and laboratory analysis. Their findings demonstrate that intensive agricultural practices are a dominant driver of nutrient enrichment in freshwater systems, particularly in regions characterized by row-crop agriculture and high fertilizer inputs. The study highlights how diffuse pollution sources are more difficult to regulate than point sources, reinforcing the importance of preventive, practice-based solutions.

This source is foundational for the present project because it establishes a clear scientific link between agricultural nutrient management and downstream water quality outcomes. By documenting how nitrogen and phosphorus from agricultural fields enter surface waters, Jabbar and Grote (2018) provide empirical justification for focusing this project on reducing nutrient runoff at the farm level. Their work supports the use of nutrient concentration metrics as key indicators in the project's monitoring framework and underscores the need for farmer-centered interventions rather than solely regulatory approaches

Chen, Y., et al. (2021). *Assessing the impacts of recent crop expansion on water quality in the Missouri River Basin using the Soil and Water Assessment Tool*. In *Journal of Advances in Modeling Earth Systems, 13(6)*. https://doi.org/10.1029/2020MS002284

Chen et al. (2021) apply the Soil and Water Assessment Tool (SWAT) in combination with Geographic Information Systems (GIS) to simulate the impacts of cropland expansion and land-use change on nitrogen and phosphorus loading across watershed systems. Their modeling approach identifies spatial hotspots of nutrient runoff and evaluates how conservation practices can mitigate nutrient transport under different land-use scenarios. The study demonstrates that targeted implementation of conservation practices can significantly reduce nutrient loads when guided by spatial analysis.

This source directly informs the methodological design of the current project. The use of SWAT and GIS modeling supports the project's emphasis on spatial targeting, monitoring, and verification. Chen et al. (2021) justify the integration of modeling outputs, GIS field maps, and scenario analysis as a means of verification for nutrient reductions. Their findings reinforce the value of combining biophysical modeling with on-the-ground conservation practices to achieve measurable watershed-scale improvements.

Veum, K., et al. (2015). *Conservation effects on soil quality indicators in the Missouri Salt River Basin.* In *Journal of Soil and Water Conservation*, 70(4), 232-246. https://www.researchgate.net/publication/279538018_Conservation_effects_on_soil_quality_indicators_CEAP-conservation_tillage-cover_cropping-SMAF-soil_

Veum et al. (2015) assessed the effects of conservation practices, including cover cropping and reduced tillage, on soil quality using indicators such as soil organic carbon, mineralizable nitrogen, and bulk density. Their research demonstrates that conservation-oriented management leads to improved soil structure, increased organic matter, and reduced erosion potential. Importantly, the study shows that soil health improvements are directly linked to enhanced nutrient retention and reduced nutrient losses to runoff.

This source supports the project's emphasis on soil health as both an environmental and agronomic outcome. Veum et al. (2015) provide evidence that conservation practices deliver tangible benefits to farmers, strengthening the economic and practical rationale for adoption. Their work informs the selection of soil-based indicators in the project LogFrame and reinforces the argument that nutrient runoff reduction and farm productivity are not competing against goals, but complementary outcomes.

Upper Mississippi River Basin Association (UMBRA). (2023). *How clean is the river? Water quality trends in the upper Mississippi River Basin*. https://umrba.org/how-clean-river-2023

This report synthesizes long-term water quality monitoring data across the Upper Mississippi River Basin, with a focus on nutrient pollution, sediment loads, and trends over time. The report identifies nitrogen and phosphorus runoff from agricultural landscapes as dominant contributors to degraded water quality, emphasizing row-crop agriculture in Midwestern states such as Missouri. The findings highlight persistent exceedances of nutrient thresholds despite localized conservation efforts, underscoring the need for broader adoption of sustainable agricultural practices.

This source directly supports the course project by providing regional evidence that nutrient runoff from agriculture remains a critical problem in northeastern Missouri watersheds. It establishes the scope and severity of the issue and justifies the project's emphasis on reducing nutrient transport to the Salt River and Mississippi River through conservation practices.

National Oceanic and Atmospheric Administration (NOAA). (2022). *The Gulf of Mexico dead zone*. https://oceantoday.noaa.gov/deadzonegulf/

This NOAA resource explains the formation, expansion, and ecological consequences of the Gulf of Mexico hypoxic zone, commonly referred to as the "dead zone." It clearly links excess nitrogen and phosphorus inputs from the Mississippi River Basin to seasonal oxygen depletion that harms fisheries, marine biodiversity, and coastal economies. The resource emphasizes agricultural runoff as the largest upstream contributor to nutrient loading.
This source strengthens the project by connecting local agricultural practices in Missouri to downstream, large-scale environmental impacts. It reinforces the importance of upstream nutrient management and provides a compelling justification for engaging farmers in conservation practices as part of a basin-wide solution.

Pierce, R.A., et al. (2022). *Establishing and Managing Cover Crops in Missouri for Wildlife and Pollinator Benefits.* University of Missouri Extension. https://extension.missouri.edu/publications/g9499

This Extension publication reviews the environmental and economic benefits of cover crops and related conservation practices, including reductions in nutrient runoff, improved soil structure, increased soil organic matter, and enhanced resilience to extreme weather. The publication also addresses cost considerations, management challenges, and long-term profitability for Missouri farmers.
This source is directly applicable to the project's implementation strategy. It supports the feasibility of cover cropping and buffer strips as both environmentally effective and economically viable, strengthening the project's assumption that farmers can adopt these practices without sacrificing profitability.

The Nature Conservancy. (2018). Sustainable agriculture in Missouri. https://www.nature.org/en-us/about-us/where-we-work/united-states/missouri/stories-in-missouri/sustainable-agriculture-in-missouri/

This resource describes conservation-based agricultural initiatives across Missouri, highlighting partnerships with farmers to improve soil health, reduce nutrient losses, and protect water quality. It presents real-world examples of incentive-based programs, technical assistance, and monitoring approaches used to scale sustainable farming practices.
This source supports the project's stakeholder engagement and adoption framework by demonstrating that collaborative, incentive-driven conservation programs are already working in Missouri. It reinforces the project's assumption that farmer participation can be achieved through targeted outreach, training, and support.

Relevance to the Project:

Collectively, these sources support every major component of the project's blueprint. They justify the selection of nitrogen, phosphorus, and soil health indicators; inform the use of GIS, SWAT modeling, and laboratory analysis; and provide evidence that conservation practices such as cover cropping and buffer strips can reduce nutrient runoff while supporting farm resilience. By grounding the project in established scientific literature and applied conservation research, this annotated bibliography ensures that the proposed initiative is evidence-based, measurable, and scalable.

2. Project Goals, Indicators, and Means of Verification

The primary goal of this project is to promote the adoption of sustainable agricultural practices among farmers in northeastern Missouri to reduce nitrogen and phosphorus runoff into the Salt River and Mississippi River watersheds. Building on the scientific literature reviewed in Week 1, the project emphasizes practices such as cover cropping and vegetated buffer strips, which have been shown to improve soil health, reduce erosion, and limit nutrient transport to surface waters (Veum et al.,2015). The goals are structured to be Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) and are supported by clearly defined indicators and robust means of verification.

Main Goal

Increase the adoption of sustainable agricultural practices among farmers in northeastern Missouri to reduce nitrogen and phosphorus runoff entering the Salt River and Mississippi River watersheds within three years.

Indicators

- Percentage reduction in nitrogen and phosphorus concentrations in surface waters (target: 10% reduction).
- Increase in total acreage managed using cover crops and buffer strips (target: 20% increase).
- Number of participating farms implementing at least one conservation practice.

Means of verification

- Water quality monitoring data from grab samples and in-stream sensors were analyzed in certified laboratories (Jabbar & Grote, 2018).
- GIS-based land-use and practice adoption of maps.
- Farmer participation surveys and enrollment records.

Assumptions and Risks

- Continued funding and technical support from partner agencies.
- Risks include extreme weather events, supply chain disruptions, and market pressures that may reduce farmer participation.

Supporting Goal 1: Reduce nutrient runoff at the Watershed scale

This goal focuses on measurable environmental outcomes by directly addressing nutrient transport pathways.

Indicators

- Modeled reductions in nitrogen and phosphorus loads using SWAT and GIS-based watershed analysis.
- Decreases in observed nitrate and phosphate concentrations at key monitoring locations.

Means of Verification

- SWAT model outputs integrated with GIS spatial analysis (Chen et al., 2021).
- USGS and project-collected water quality datasets.
- Laboratory analysis of nutrient concentrations.

Assumptions and Risks

- Assumes the availability of up-to-date spatial and hydrologic data.
- Risks include data gaps, model uncertainty, and variability caused by precipitation extremes.

Supporting Goal 2: Improve soil health on participating farms

Improving soil health is critical to sustaining long-term nutrient reductions and farm productivity.

Indicators

- Increases in soil organic carbon.
- Improvements in mineralizable nitrogen and bulk density.
- Reduction in visible erosion indicators on treated fields.

Means of Verification

- Soil sampling and laboratory analysis following established protocols (Veum et al., 2015).
- Field observations and photographic documentation.
- GIS-linked soil health records for participating parcels.

Assumptions and Risks

- Assume farmers maintain practices long enough for soil improvements to be measurable.
- Risks include delayed soil response and inconsistent practice implementation.

Supporting Goal 3: Increase farmer knowledge and long-term behavioral change

This goal incorporates peer feedback, emphasizing the importance of education, trust, and sustained adoption.

Indicators

- Farmer knowledge gains are measured through pre- and post-training surveys.
- Adoption of multiple conservation practices over time.
- Continued participation beyond initial enrollment.

Means of Verification

- Training attendance records and workshop evaluations.

- Follow-up surveys and on-farm visits.
- Documentation of repeat or expanded practice adoption.

Assumptions and Risks

- Assume farmers perceive the practices as economically and operationally feasible.
- Risks include skepticism, unequal access to resources, and competing time demands.

Integration with Project Design

Together, these goals form a cohesive framework linking environmental outcomes, farm-level benefits, and behavioral change. Indicators are grounded in peer-reviewed research and established monitoring practices, while verification methods rely on a combination of field data, modeling, and stakeholder engagement. This structure ensures transparency, accountability, and adaptability, positioning the project for meaningful and measurable impact at both the farm and watershed scales.

3. Project LogFrame

Logical Frameworks Overview

This project applies to the Logical Framework Approach to ensure a clear, results-oriented structure linking activities to outputs, outputs to outcomes, and outcomes to the overall project goal. The LogFrame provides a transparent pathway for implementation, monitoring, and evaluation, while explicitly addressing risks and assumptions that could influence success (Couillard et al., 2009).

LogFrame table

	Project Summary	Indicators	Means of Verification	Risk / Assumptions
Goal	**Increase the adoption of cover crops and buffer strips among the farmers in northeastern Missouri to reduce nutrient runoff.**	Number of farmers adopting cover crops and buffer strips. Percentage increase in acres planted with cover crops. Percentage of field edges or waterways protected with buffer strips. Reduction in modeled nitrogen and phosphorus runoff from participating fields.	Farmer participation forms and surveys. GIS field maps using ArcGIS. Drone images validate the presence of cover crops and buffer strips. Soil and water test results.	***Risks:*** Farmers may resist due to costs, labor, and low yields, while extreme weather, limited resources, weak outreach, and technical failures further hinder the adoption of conservation practices. ***Assumptions:*** Farmers are more likely to participate if incentives and guidance are available. Stable funding and staff will support continuity of efforts. Effective collaboration with local agencies strengthens project implementation, and consistent access to farms and sampling sites allows activities to proceed smoothly. Reliable GIS and monitoring technologies further support accurate data collection and evaluation.
Outcomes	**1. Reduced nitrogen and phosphorus runoff.** This outcome reflects the environmental changes expected after farmers	Percent reduction in nitrogen and phosphorus concentrations in nearby waterways.	Water sampling data collected using automated sensors and laboratory nutrient analysis, modeled runoff data using tools	***Risks:*** Extreme rainfall events that increase runoff regardless of farming practices. Lack of consistent water

	adopt conservation practices. Research in Missouri's agricultural watersheds shows that nutrient runoff decreases significantly when conservation systems are implemented (Jabbar & Grote, 2018; Veum et al., 2015).		such as SWAT (Chen et al., 2021), and watershed monitoring reports from the Missouri Dept of Natural Resources (MoDNR).	access points for sampling. ***Assumption:*** Farmers will implement conservation practices. Access to water sampling sites is maintained.
	2. Improved soil health. This outcome aligns with evidence that ecological farming practices increase soil organic carbon, aggregate stability, and biological activity (Kremer & Hezel, 2013).	Percent increase in soil organic carbon. Improvement in soil aggregate stability scores.	Laboratory soil tests, field sampling with soil probes, and digital record-keeping of soil health metrics using GIS-based soil monitoring tools.	***Risks:*** Soil improvements may take longer than the project's timeline; drought conditions could affect soil readings. ***Assumptions:*** Farmers follow recommended soil management guidelines and allow soil sampling.
Outputs	**1. A complete farmer training and outreach program on cover crops and buffer strips.** This output represents a tangible deliverable produced by project activities.	Number of workshops delivered. Number of farmers trained.	Attendance logs, workshop materials, pre/post training surveys, and digital learning module records.	***Risks:*** Low farmer participation as Low farmer participation as scheduling conflicts may occur during planting and harvest seasons. ***Assumptions:*** Farmers are willing to attend training when offered flexible scheduling and incentives.
	2. GIS-based maps showing the adoption of conservation practices across participating farms. This output provides a visual and analytical product to track where practices are being implemented.	Number of farms mapped. Spatial coverage of cover crops and buffer strips.	GPS field mapping, drone imagery, GIS software such as ArcGIS or QGIS, and farmer-reported geospatial data.	***Risks:*** Technical barriers, such as a lack of GPS accuracy. Farmers are unwilling to share field boundary information. ***Assumptions:*** Access to GIS tools and adequate training for project staff.
Activities	**1. Conduct workshops, field demonstrations, and technical assistance for farmers.** This activity produces farmer training output and supports the adoption of sustainable practices.	Number of demonstration plots established. Number of technical assistance visits completed.	Demonstration of field records, sign-in sheets, field visit documentation, and extension of service reports.	***Risks:*** Weather disruptions affecting field demonstrations; limited staff capacity for site visits. ***Assumption:*** Sufficient funding and staffing are available to deliver educational activities.

	2. Collect soil samples, water samples, and geospatial data using environmental monitoring technologies. This activity generates the data necessary to produce soil and water quality outputs and verify outcomes.	Number of soil samples and water samples collected. Number of geospatial field data points recorded.	Soil and water lab reports, GPS logs, drone footage, and digitally stored datasets.	***Risks:*** Equipment malfunction or data loss may occur. Restricted access to sampling sites. ***Assumption:*** Field technicians are trained, and equipment is available and functional.

**This table was generated with the assistance of ChatGPT genAI*

4. Project Brief

Introduction

Agricultural nutrient runoff is one of the most significant nonpoint source pollution challenges affecting water quality in the United States, with nitrogen and phosphorus losses from croplands contributing directly to eutrophication in downstream water bodies. In northeastern Missouri, intensive corn and soybean production has led to elevated nutrient runoff into the Salt River and Mississippi River watersheds, exacerbating harmful algal blooms and contributing to hypoxic conditions in the Gulf of Mexico. Addressing this issue requires solutions that balance environmental protection with the economic realities faced by farmers.

This project proposes a community-based sustainability initiative that promotes the adoption of cover cropping and buffer strips among farmers in northeastern Missouri to reduce nutrient runoff while maintaining or improving farm profitability. By integrating farmer training, demonstration plots, GIS-based monitoring, and environmental data analysis, the project aims to achieve measurable reductions in nitrogen and phosphorus losses and foster long-term behavioral change in agricultural management.

Literature Review

Extensive research demonstrates that agriculture is a dominant source of nonpoint source nutrient pollution in U.S. watersheds. Jabbar and Grote (2018) documented elevated nitrate and phosphate concentrations in agricultural runoff, showing clear links between fertilizer application, dissolved oxygen depletion, and downstream water quality degradation. These findings highlight the need for targeted interventions at the farm level to mitigate nutrient transport before it enters surface waters.

Modeling studies further emphasize the spatial variability of nutrient runoff and the importance of identifying high-risk areas. Chen et al. (2021) applied the Soil and Water Assessment Tool (SWAT) combined with GIS analysis to simulate nitrogen and phosphorus loads under different land-use scenarios. Their work demonstrated that cropland expansion significantly increases nutrient exports, and that conservation practices can meaningfully reduce nutrient loads when strategically implemented. Such modeling approaches provide a scientific foundation for prioritizing interventions and monitoring outcomes.

Soil health is a critical mediating factor in nutrient retention and runoff reduction. Veum et al. (2015) assessed conservation practices using soil organic carbon, mineralizable nitrogen, and bulk density as indicators, finding that cover crops and reduced disturbance improved soil structure, increased nutrient retention, and reduced erosion. These improvements not only benefit water quality but also enhance long-term agricultural productivity.

Beyond biophysical impacts, farmer decision-making and knowledge play a decisive role in conservation adoption. Regional assessments show that nutrient runoff from tributaries such as those in northeastern Missouri cumulatively contributes to basin-scale water quality degradation (UMRBA, 2023). National-scale impacts, including the Gulf of Mexico hypoxic zone, underscore the importance of pairing environmental monitoring with farmer education and business-oriented tools (NOAA, 2022).

Together, the literature supports a multifaceted approach that integrates conservation practices, soil health monitoring, spatial analysis, and stakeholder engagement. These findings directly inform the design of this project by identifying effective practices, appropriate indicators, and reliable verification methods.

Existing Approaches

Several prior initiatives provide valuable lessons for addressing nutrient runoff through sustainable agriculture. One prominent example is the application of SWAT-based watershed modeling to guide conservation planning. Chen et al. (2021) demonstrated how combining SWAT simulations with GIS mapping can identify nutrient hotspots and evaluate the effectiveness of conservation practices. While this approach is highly effective for planning and evaluation, it often lacks direct farmer engagement, limiting on-the-ground adoption.

Another relevant approach is the implementation of conservation practice programs supported by farmer training and technical assistance. Veum et al. (2015) showed that field-based conservation efforts, combined with soil monitoring, can produce measurable improvements in soil health and erosion control. However, these projects often focus on environmental outcomes without fully integrating economic metrics that are critical for farmer buy-in.

This project builds these approaches by integrating robust modeling and monitoring tools with farmer-centered training, demonstration plots, and sustainable business model development. By addressing both environmental and economic dimensions, the project aims to overcome limitations observed in previous efforts and achieve a scalable, long-term impact.

Project Plan and Potential Impact

The primary goal of this project is to promote the sustainability of agricultural activities in northeastern Missouri by increasing farmer adoption of cover cropping and buffer strips to reduce nitrogen and phosphorus runoff into the Salt River and Mississippi River watersheds. Success will be measured through a 10% reduction in nutrient concentrations at monitoring sites and a 20% increase in acres managed with sustainable practices within three years.

The project is structured around two key outcomes. First, increased adoption of conservation practices will be achieved by engaging at least twenty-five farmers and implementing cover crops and buffer strips across a minimum of 2,000 acres. Second, improved soil health and reduced nutrient transport will be measured using soil quality indicators and SWAT-based modeling.

To support these outcomes, the project will deliver two main outputs. The first is a farmer training and technical support program consisting of workshops, one-on-one consultations, and demonstration plots. These activities are designed to improve farmer knowledge, reduce perceived risks, and highlight economic benefits. The second output is a suite of GIS-based monitoring products, including conservation adoption maps and nutrient hotspot analyses, which will support evaluation and communication with stakeholders.

Environmental monitoring will play a central role in verifying project impacts. Soil samples will be analyzed for organic carbon and nutrient indicators, while water samples will be collected to measure nitrogen and phosphorus concentrations. GIS mapping, drone imagery, and SWAT modeling will be used to track changes over time and identify areas of greatest impact.

The potential impact of this project extends beyond immediate nutrient reductions. By fostering long-term behavioral change among farmers, the initiative aims to improve watershed health, enhance soil resilience to extreme weather, and provide a scalable model for sustainable agriculture in similar regions.

Interested and Affected Parties (IAPs)

Several IAPs are central to the success of this project. **Farmers** are the primary participants and beneficiaries, as they directly implement conservation practices and experience both costs and benefits. **Local watershed communities** are affected by changes in water quality and ecosystem health. **Conservation organizations** such as the Missouri Coalition for the Environment play a critical role in outreach, education, and stakeholder coordination. **State and federal agencies**, including the USDA NRCS and USGS, provide technical guidance, data resources, and potential funding support. Recognizing the diverse perspectives and constraints of these groups is essential for equitable and effective project implementation.

Conclusion and Call to Action

Nutrient runoff from agricultural lands poses a persistent threat to water quality, ecosystem health, and downstream communities. Reducing this requires collaboration, trust, and evidence-based planning. This project offers a practical, science-based pathway to improve water quality while strengthening agricultural sustainability. Through targeted training, demonstration, and rigorous monitoring, the initiative seeks to achieve measurable reductions in nitrogen and phosphorus losses while strengthening the economic and environmental resilience of northeastern Missouri agriculture. Stakeholders, community leaders, and decision-makers are encouraged to support and participate in this initiative, recognizing that sustainable farming practices are not only an environmental necessity but also a foundation for long-term agricultural viability and watershed health.

5. Appendix

a. Feedback Table

Section of Project Blueprint	Feedback received from peers and/or instructor	Revisions made based on feedback	Revisions made based on new learning
Annotated Bibliography	***Instructor:*** The sources used are strong, relevant, and well synthesized. Consider adding a brief note stating how each source directly informs the course project.	Explicitly referenced how each study informs project design (e.g., SWAT modeling for runoff reduction, soil quality indicators for monitoring effectiveness). Clarified the practical relevance of each source to farmer adoption, monitoring, and policy alignment in the Project Brief.	Gained a clearer understanding of how to move from literature review to applied project planning by explicitly linking research findings to proposed methods and indicators.
Project Goals, Indicators, and Means of Verification	***Instructor:*** Recommended three indicators: nitrogen and phosphorus levels, soil organic carbon, and farmer knowledge scores. Suggested using water quality sensors, GIS mapping, and surveys for data collection, and adding a separate title page for the final report. ***Peer:*** Add socio-economic indicators and long-term behavioral change metrics.	Refined goals to explicitly focus on reducing nutrient runoff while maintaining farm profitability. Strengthened means of verification by integrating lab data, GIS mapping, surveys, and modeled outputs. Added economic indicators like fertilizer cost reduction and net profit changes.	Learned how to balance environmental and economic indicators to create goals that are both scientifically rigorous and realistic for farmer adoption. Will also use a separate title page for the final report.
Project LogFrame	***Instructor:*** LogFrame is robust and well structured. Objectives are well defined and justified by quantifiable goals. Monitoring approaches using GIS maps, drone imagery, and soil and water analyses are effective. Outputs and activities are realistic, evidence-based, and aligned. Risks and assumptions	Retained the overall LogFrame structure due to strong alignment with best practices. Clarified language linking modeled nutrient reductions directly to soil health improvements and conservation adoption.	Gained confidence in applying the Logical Framework Approach correctly, especially in aligning indicators and verification methods with real-world monitoring technologies.

	appropriately address weather extremes, farmer resistance, technical barriers, and resource limitations.	Ensure consistency between indicators, outputs, and activities to strengthen traceability across the LogFrame.	
Project Brief	***Instructor:*** Suggested integrating training, demonstration plots, GIS/drone monitoring, and lab analysis. Also asked how long-term adoption would be ensured despite risks. ***Peer:*** Recommended addressing equity, socio-economic impacts, and strengthening verification methods.	Modified the project brief to explicitly integrate training, demonstration plots, GIS, drone imagery, SWAT modeling, and laboratory analysis. Added discussion of long-term behavior change, economic incentives, and adaptive management strategies. Included equity considerations for small landowners and farmers.	Improved ability to synthesize technical methods, stakeholder engagement, and risk mitigation into a cohesive, persuasive project narrative.

b. Reference List

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