Environment and Natural Resources Trust Fund

M.L. 2026 Approved Work Plan

General Information

ID Number: 2026-300

Staff Lead: Tom Dietrich

Date this document submitted to LCCMR: May 26, 2026

Project Title: Sustainable Land Use with Robotic Technology on Small Farms

Project Budget: $524,000

Project Manager Information

Name: Ji Youn Shin

Organization: U of MN - College of Design

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Project Reporting

Date Work Plan Approved by LCCMR: June 17, 2026

Reporting Schedule: April 1 / October 1 of each year.

Project Completion: June 30, 2029

Final Report Due Date: August 14, 2029

Legal Information

Legal Citation: M.L. 2026, Chp. 104, Sec. 2, Subd. 08l

Appropriation Language: $524,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to collaborate with the Hmong American Farmers Association to design and test new robotic technologies to assist with sustainable agricultural practices on small farms.

Appropriation End Date: June 30, 2029

Narrative

Project Summary: Working with the Hmong American Farmers Association, this project will customize robotic technologies for use on small farms and train farmers to incorporate these robots into their traditional agricultural practices.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota's agricultural crop production is vital to its economy, ranking fifth in the U.S. and generating $12.9 billion in profits. The state is a leading producer of crops such as sweet corn and green peas. Over the past century, Minnesota has warmed by nearly 3°F, with annual rainfall increasing by 3.4 inches. Excessive precipitation disrupts agriculture by delaying planting, causing soil erosion, and degrading farmland, threatening sustainability. Small farms, including community-based farms, employ techniques like crop rotation, intercropping, and adaptive planting to handle varying weather and reduce soil erosion. While these methods enhance resilience, they are labor-intensive and inefficient. As a result, interest in smart farming technologies, such as robotics, is growing. However, adopting robotics remains challenging due to high costs, training gaps, and difficulties integrating automation with diverse planting strategies developed. Additionally, concerns about job displacement and the ability of robots to navigate uneven terrain and waterlogged soil hinder adoption. Developing adaptable robotic technologies suited to diverse landscapes and soil conditions can enhance small farms' productivity and resilience while integrating their experiential knowledge for sustainability. As small farms support local food systems and rural economies, this study will make a significant contribution to the state.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

The long-term goal of this project is to promote sustainable land use, ensure access to fresh and healthy food in local communities, and strengthen small farms' role in resilient agriculture. To achieve this, the project has three main phases: (1) identify specific farmer needs, current gaps, and customization requirements for robotic technologies to assist with diverse crop-planting systems on small farms; (2) develop and implement robotic solutions capable of traveling in narrow alleys between crops, navigating uneven terrain and waterlogged soils, and assisting farmers in improving efficiency while minimizing environmental impact, incorporating findings from the previous phase; and (3) empower small-scale farmers through training and field testing, enabling them to adopt and maintain robotic technologies beyond the research phase while integrating automation with traditional farming knowledge and techniques, such as crop rotation, intercropping, and soil conservation practices.

A team of robotics engineers and design scholars will collaborate with the Hmong American Farmers Association (HAFA), a nonprofit farming organization in Minnesota that provides education, training, and assistance in sales. This partnership will allow the team to implement a comprehensive robotic service package—including a robot, training, and maintenance support—with the potential for future broader adoption across small farms in Minnesota.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The outcomes of this project will provide solutions to challenges in small farm operation and land sustainability. By developing, demonstrating, and evaluating new robotic technologies on small farms in Minnesota, we aim to improve soil health, optimize water usage, and enhance the productivity of fresh, healthy local crops—ultimately benefiting local ecosystems and communities. Additionally, this project will provide integrated training and maintenance plans for the robots and will specifically customize robots for operation on small farms. Collaboration with a nonprofit farmers' organization will foster partnerships with local communities to strengthen land stewardship and conservation efforts.

Project Location

What is the best scale for describing where your work will take place?

Region(s): Metro

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Phase 1: Needs Assessment to Identify Design Implications and Customization Requirements for Robotics on Small Farms

Activity Budget: $223,000

Activity Description:
Objectives and Activities:

To understand small farm practices and identify key design considerations for robot use, the research team will conduct multiple interviews and co-design sessions with farmers and HAFA staff. Additionally, expert interviews with agricultural professionals will help define the criteria for robot customization.
Farmer and staff interviews will explore farming experiences, the role of crop diversification in risk mitigation, environmental challenges, weather-related risk management strategies, and perceptions of advanced technologies.
Expert interviews will focus on technological challenges in small-scale farming, the current infrastructure supporting the implementation and management of farming tools, and potential opportunities.
Co-design sessions will be integrated into group training sessions and orientations at HAFA. Using human-centered design approaches, we will engage farmers and staff in envisioning ideal robotic solutions for daily farming tasks and generating diverse design ideas. Robot prototyping will be initiated and iteratively refined based on the identified design criteria.
Outcomes:

1) Completed and transcribed interview records in text format
2) A handbook of robot design guidelines, co-design outcomes, and initial robot prototypes.
3) Two peer-reviewed manuscripts prepared for dissemination within scholarly communities

Activity Milestones:

Description	Approximate Completion Date
Conduct 18 interviews and 2 co-design sessions with 20 farmers and HAFA staff	January 31, 2027
Conduct 12 expert interviews with agricultural professionals to help define the criteria for robot customization	January 31, 2027
Completed transcript of interviews	February 28, 2027
A handbook of robot design guidelines, accompanied by photographs of co-design outcomes	June 30, 2027
An initial robot prototype	June 30, 2027
Two peer-reviewed manuscripts prepared for dissemination within scholarly communities	September 30, 2027

Activity 2: Phase 2a: Development of Robots Based on the Design Implications and Frameworks Identified in Phase 1

Activity Budget: $79,000

Activity Description:
Objectives and Activities:
The primary objective of Phase 2 is to develop robots for pilot testing and evaluation in real-world farming environments. The robots will need to operate in narrow alleys between rows of crops, travel on rough terrain and waterlogged soils, and operate autonomously over paths that vary from farm to farm. The tasks the robots will perform include autonomous movement across the farm, weed monitoring, video recording, weed treatment, and fertilizer application. The robots should be easy to use and capable of operating autonomously after a quick initial setup by each

farmer. The customized robot platform developed in the project will be tailored to the needs identified in Phase 1. In particular, the project will utilize a rugged robot platform with low-cost sensors, an intelligent suspension system that allows travel on rough terrain, RTK-corrected GPS, and on-board control systems and processors for autonomous operation, data recording, and fertilizer application and weed treatment systems.

Outcomes:
1) Prototypes and functional robots capable of rugged operation on farms without breakdowns.
2) Knowledge dissemination through reports, websites, social media, and conference publications.

Assessment:
Successful completion will be assessed based on the robots' ability to autonomously perform the defined tasks across diverse terrains.

Activity Milestones:

Description	Approximate Completion Date
Initial prototypes of robots created using low-fidelity materials (e.g., cardboard, foam board)	September 30, 2027
Equip 1 robot in laboratory for future field deployment	December 31, 2027
Posts on blog, LinkedIn, MnRI newsletter, and College of Design newsletter sharing robot design progress	May 31, 2028
Functional robots operating autonomously on small farms, handling rough terrains and waterlogged soils	June 30, 2028
A peer-reviewed manuscript prepared for dissemination within scholarly communities	September 30, 2028

Activity 3: Phase 2b: Development of Training and Maintenance Plans, and a Service Blueprint for the Community

Activity Budget: $64,000

Activity Description:
Objectives and Activities:
Successfully integrating robotics into small-scale farming requires comprehensive training and support systems alongside technological innovation. The second objective of Phase 2 is to develop training and maintenance programs in collaboration with the farming community. The team will use an iterative design approach to determine the most suitable training platform and concept for the community. Additionally, user-friendly training modules (e.g., interactive storytelling) will be created to highlight the robot's role in enhancing soil health and promoting sustainable land use, while integrating farmers' traditional practices and knowledge. The training content will emphasize that robotics are designed to support, not replace, farmers. A maintenance manual will also be developed for HAFA and the community to ensure long-term sustainability and effective implementation of robotics on small farms.

Outcomes:
1) Video training modules on soil health, sustainable land use, and robot operation
2) Maintenance handbook for farmers' independent use of robotics
3) A service blueprint diagram illustrating community integration and sustainable use of robots
4) A peer-reviewed manuscript prepared for dissemination within scholarly communities

Assessment:
Farmers and HAFA staff will review and validate the training content. The effectiveness and feasibility of these materials will be tested in Phase 3.

Activity Milestones:

Description	Approximate Completion Date
Video training modules on soil health, sustainable land use, and robot operation	September 30, 2027
A maintenance handbook for farmers' independent use of robotics	June 30, 2028
A service blueprint diagram illustrating community integration and sustainable use of robots	June 30, 2028
A peer-reviewed manuscript prepared for dissemination within scholarly communities	September 30, 2028

Activity 4: Phase 3: Field Deployment of Robotics on Small Farms to Understand Feasibility of the Technology and Identify Criteria for Improvement

Activity Budget: $158,000

Activity Description:

Objectives and Activities: This phase aims to assess the feasibility and effectiveness of robots in supporting sustainable land use. Robots will be deployed on HAFA farms for one month, during which data will be logged from the robots (e.g., usage data, task completion rates, operational performance), and follow-up interviews will be conducted with farmers and staff. Farmers' labor productivity (e.g., crops harvested, soil prepared per unit of labor input) and resource utilization (e.g., efficient use of water and fertilizers to minimize waste while maintaining soil and crop health) will serve as indicators of the robot's feasibility and effectiveness. Additionally, this phase will identify practical challenges faced by these technologies in real-world settings, offering opportunities for future refinement and application to other small-scale farms across the state/region.

Outcomes:
1) Completion of training sessions enabling farmers and HAFA staff to independently operate the robots
2) Data collected from field deployment, including detailed usage records, productivity, and interview transcripts
3) Documented list of modification items for robot design improvements
4) Two manuscripts prepared for dissemination within scholarly communities

Assessment: Through data logs and interviews, we will critically evaluate the prototypes' feasibility, determining their effectiveness in improving productivity.

Activity Milestones:

Description	Approximate Completion Date
Completion of training sessions enabling farmers and HAFA staff to independently operate the robots	December 31, 2028
Deploy robot with 16-20 farmers and conduct follow up interviews	June 30, 2029
Data collected from field deployment, including detailed usage records, productivity, and interview transcripts	June 30, 2029
Documented list of modification items for robot design improvements	June 30, 2029
Two manuscripts prepared for dissemination within scholarly communities	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Rajesh Rajamani	University of Minnesota	Co-Project Manager	Yes
Janssen Hang	Hmong American Farmers Association (HAFA)	Collaborator	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
We consider four main activities as part of our dissemination efforts: (1) communicating knowledge and project findings about sustainable land use on small farms in accessible language through social media channels, (2) providing education and maintenance instructions for members of small farming communities, (3) seeking feedback and guidance from robot engineers and community-engaged designers to refine outcomes at each phase of the project through academic publications and conference presentations in the US and abroad, and (4) offering students educational opportunities in classroom and lab settings by sharing the research team's experiences with the College of Design and the College of Engineering at the University of Minnesota.

First, to promote understanding of land management on Minnesota's small farms and encourage protective practices, we will use social media channels such as YouTube to share our findings on applying suitable robotic technologies in small-scale farming communities. For example, we will produce a short, accessible video showing how the team collaborates with small farming communities in Minnesota, supported by the Environment and Natural Resources Trust Fund. These communications will highlight the positive impacts of advanced technologies (including robots) on sustainable land use in Minnesota and the potential benefits of reducing reliance on pest control and other chemical materials.

Second, as part of our participatory design, we will hold co-design of robots and training sessions with farmers in small communities and staff members. Direct involvement of end users on small farms will ensure that results are shared with key stakeholders, enabling them to see the impact of their input and to identify practical ways to improve resource management in Minnesota.

Third, sharing findings from each project phase with robotics engineers and designers will help the team refine products and better prepare for the next phase of the study. To achieve this, we will disseminate outcomes from each phase of our research at relevant conferences (e.g., ACM CHI Conference on Human Factors in Computing Systems (CHI), ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW)). These manuscripts and presentations will address topics such as design guidelines for robot use in promoting sustainable land use on small-scale farms; a framework for smart agricultural technologies to inform future research and robot development; the development process for functional robots capable of rugged operation on small farms without breakdowns; and findings on how farming communities in Minnesota use robots on small farms, based on the feasibility and effectiveness of field deployments and pilot testing.

Fourth, this proposed work will offer mentoring and teaching opportunities for students through hands-on participation in co-design workshops, robot prototyping, and technology development for small farms. Engaging in projects that emphasize sustainable land use through emerging technologies will provide students with practical experience while

advancing their training and professional development. By involving students in both design conceptualization and development, this research will help ensure the longevity and impact of its outcomes.

We will acknowledge the Environment and Natural Resources Trust Fund by including a statement, the trust fund logo, and/or attribution language in all outreach efforts, including publications, articles, educational materials, and other communications.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

In collaboration with HAFA, we will ensure that farmers in their network have access to a customized robot at a minimized cost. Beyond this project, we will seek other future funding to expand into broader agricultural sustainability programs, scaling these practices to other small farms across Minnesota, including community-supported farms, Indigenous farming groups, and farmer training programs. This research team has a strong track record of successfully securing research grant funding from federal agencies, including the National Science Foundation (NSF). In particular, the team will pursue funding from the National Institute of Food and Agriculture (NIFA) and joint NIFA-NSF programs.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager Shin		To lead research project activities and reporting			26.7%	0.66		$112,000
Co-Project Manager Rajamani		To lead robot development			26.7%	0.12		$49,000
Postdoc		To work intensively on robot development			20.5%	2.01		$176,000
Grad Research Assistant		To support participatory design, data collection, prototype, and evaluation			46%	0.93		$108,000
							Sub Total	**$445,000**
Contracts and Services								
TBD	Service Contract	Translation for Hmong language interview data				0.04		$2,000
Hmong American Farmers Association	Subaward	To coordinate participant recruitment, support farmer outreach and engagement, consult on robotics design and training tools.				0.2		$10,000
							Sub Total	**$12,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Craft materials for participatory design with farmers, including clay, blocks, Legos, drawing tools, colored paper, fabric	Materials for participatory design session with farmers					$2,000
							Sub Total	**$2,000**
Capital Equipment								
		All terrain robot	The project will purchase a robot capable of traveling on very rough terrains with rugged high traction wheels. The robot will be	X				$50,000

			instrumented with wheel encoders, RTK-corrected dual antenna GPS sensors, multiple cameras, infrared sensors, radar sensor, GPU processors capable of running image processing, deep learning, data acquisition and real-time control algorithms. The project will take a two-step approach towards robot development in which expensive and reliable sensors will initially be utilized and then a lower-cost prototype using less expensive sensors will be created and their performances compared.					
							Sub Total	**$50,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	30 trips, approx 70 miles per trip at 70 cents per mile	To visit farms during field deployment for data collection					$1,250
							Sub Total	**$1,250**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	1 conference (y3)	To present research project findings at CHI Conference on Human Factors in Computing Systems	X				$2,250
							Sub Total	**$2,250**
Printing and Publication								
	Publication	(4) open access publications ($750/publication)	To disseminate findings in top-tier peer review and relevant trade journals. Most peer-reviewed, academic publications related to this					$3,000

			research will be disseminated in open-access journals focused on Human-Computer Interaction (HCI). The research team anticipates publishing four journal articles or conference papers during the project in the following venues: CHI Conference on Human FActors in Computing Systems, Conference on Computer-Supported Cooperative Work & Social Computing (CSCW) proceedings, Designing Interactive Systems Conference (DIS) proceedings. The prevailing OA publication fee is approximately $750 per publication.					
							Sub Total	**$3,000**
Other Expenses								
		Research Stipends	Research stipends are requested for approx 70 research participants at the following rates for individuals: $50 for co-design sessions (20 participants), $30 for interviews in phase 1 (30 participants); $75 for deployment in phase 3 (20 participants). Stipends are typically paid to participants by a Visa gift card or similar tender. The rate is determined by the amount of time required of research participants and level of engagement (group activities versus individual interviews). Stipends are paid to research participants to incentivize participation and help to ensure high recruitment and retention for the duration of the study.					$3,500
		Transcription	To transcribe interview research data for qualitative assessment					$5,000
							Sub Total	**$8,500**
							Grand Total	**$524,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Equipment		All terrain robot	Development of robot is intended to support and be used by small scale farms. **Additional Explanation :** The team will continue to use the robot platform for developing and evaluating technology that can assist farmers on small farms.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	1 conference (y3)	In Year 3 (2029) the research team will publish and present the study outcomes at one of the most prestigious venues in the field: the CHI Conference on Human Factors in Computing Systems, where thousands of international scholars gather to exchange ideas. These conferences are held in rotating international locations across North America, Europe, and Asia. While the exact locations for the coming years have not yet been announced, they will be within these regions. Given the significance of the current research topic and its potential impact in computing, community-engaged design, and robotics, we aim to disseminate the work at a large, international venue rather than in a smaller, local context. ACM proceedings require $700- $1000, depending on the membership status.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Unrecovered F&A at the rate of 54% (negotiated indirect cost rate agreement).	Support for Product Design and Mechanical Engineering facilities where work will be conducted.	Secured	$250,000
			Non State Sub Total	**$250,000**
			Funds Total	**$250,000**

Total Project Cost: $774,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7e7726e4-a73.pdf

Alternate Text for Visual Component

The research team conducted preliminary observations and interviews at HAFA from summer to winter of 2024 to understand current small-scale farming practices. This research project proposal has been formulated based on our detailed understanding of how farmers working on small farms can be helped....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Support Letter from Hmong American Farmers Association	fa77bf89-d88.pdf
UMN Sponsored Projects Admin Authorization	d0127e68-ef9.pdf
UMN SPA Authorization Letter	d736997d-3b3.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

05/26/2026

We made two changes following discussions with the Project Analyst & Grant Monitoring Specialist, Tom Dietrich. First, we revised the timeline to begin robot development in Year 1 instead of Year 2 to allow more time to address potential issues in real-world settings. This change only affects the allocation of robot development-related budgets across the three years, including moving the robot purchase fee from Year 2 to Year 1. It does not affect the total budget or overall project goals.
Second, we revised the summer salary allocation by slightly reducing the RA summer work portion and increasing the PI summer work portion due to changes in the project situation (the student will travel during the summer). This adjustment will not affect the project goals, scope, or total budget.

11/7/2025

Since our workshop will not exceed three hours, we have removed the $1,000 allocated for refreshments from the budget. We have reallocated the remaining $1,000 to Capital Expenditures, Equipment, Tools, and Supplies to support the participatory design activities. We also updated “Research Subject Payments” to “Research Stipends.”

We have changed our answer to the question, "Does your project include original, hypothesis-driven research?" from "yes" to "no" on the General Information page (Tab 3). We received an email from Lisa Bigaouette informing us that the committee has determined our project does not include original, hypothesis-driven research and therefore does not require peer review. We agree with this decision and updated this part.

As LCCMR permits 1 person to attend 1 out of state conference per project, we revised the travel budget accordingly. Travel costs are now limited to 1 out-of-stage conference in Year 3 for dissemination ($2,500) and $500 in-state travel costs for each project year to visit the HAFA farm and dissemination (mileage at the IRS rate of 70 cents/per mile, according to UMN policy).

We have reduced the budget to align with the recommended amount of $524,000. Out-of-state travel has been reduced to 1 trip for 1 person during the project. Additionally, the Graduate Research Assistant's time has been reduced from 50% to 25% in Y3.

We have added the dissemination plans for the project

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

Yes

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

No

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this project:

Sarah Acosta, Alexandra Sullivan, The Regents of the University of Minnesota

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand