Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-300

Proposal Title: Sustainable Land Use on Small-Farms through Collaborative Robots

Project Manager Information

Name: Ji Youn Shin

Organization: U of MN - College of Design

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Project Basic Information

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.

ENRTF Funds Requested: $562,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Land (F)

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

Narrative

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.

Activities and Milestones

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

Activity Budget: $104,000

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 and orientations at HAFA. Using human-centered design approaches such as journey mapping, crafting, and scenario-based discussions, we will engage farmers and staff in envisioning ideal robotic solutions for daily farming tasks, fostering various design ideas.

Outcomes:
1) Design guidelines for robot use in small-scale farming.
2) A framework for smart agricultural technologies to inform future research and robot development.
3) Knowledge dissemination through reports, websites, social media (e.g., YouTube), and conference publications.

Assessment:
Agricultural experts, HAFA staff, and farmers will review the framework for validation and feedback before integration into robot prototypes.

Activity Milestones:

Description	Approximate Completion Date
Design implications and development framework for customized robot use on small farms.	June 30, 2027

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

Activity Budget: $169,000

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) 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
Functional robots operating autonomously on small farms, handling rough terrains and waterlogged soils.	June 30, 2028

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

Activity Budget: $69,000

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) Training modules on soil health, sustainable land use, and robot operation.
2) A maintenance manual to support farmers' independent implementation of robotics.
3) A holistic service blueprint illustrating how robots can be integrated into the community and sustained through tailored training and maintenance.

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

Activity Milestones:

Description	Approximate Completion Date
Training and maintenance plans and a service blueprint for the community.	June 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: $220,000

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) Empirical data and design implications for using robots on small farms, based on the feasibility and effectiveness of field deployments/pilot testing.
2) Farmers and HAFA staff fully trained to operate the robots.
3) Knowledge dissemination through reports, websites, social media, and conference publications.

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

Activity Milestones:

Description	Approximate Completion Date
Empirical understanding of robot feasibility for small farms and identification of criteria for improvements.	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

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.

Project Manager and Organization Qualifications

Project Manager Name: Ji Youn Shin

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.

The Project Manager (PM), Shin, aims to design interactive technologies that facilitate human-robot collaboration and explore their role in transforming users' practices, relationships, and dynamics. Her research employs participatory design to develop technologies that align with users' needs across varying contexts, including agriculture, chronic disease patient care, and family-centered health management. Her work has been published in top-tier venues like CHI (Conference on Human Factors in Computing Systems), DIS (Designing Interactive Systems), and CSCW (Computer-Supported Cooperative Work).

The PM is uniquely positioned to lead this research due to her expertise in designing interactive technologies in community-driven settings, a history of successful interdisciplinary collaborations, and access to resources in the College of Design and the College of Science and Engineering at the University of Minnesota. Her background in participatory design and human-robot interaction aligns with the project's goal of developing collaborative farming technologies that promote sustainable land use, strengthen small farms' roles in climate-resilient agriculture, and incorporate farmers' traditional knowledge and practices.

To ensure successful implementation and evaluation, the PM has assembled an interdisciplinary team with expertise in robotics, community-based farming, and design. This team will guide the assessment of research outcomes and help translate findings into practical applications for sustainable land use in Minnesota and beyond. The PM has established strong partnerships and trust with HAFA over the last two years, which has led to the development of this study. Co-PM Rajamani has a proven long-term track record of securing research grant funding from many federal agencies. As Associate Director of the Minnesota Robotics Institute, his research focuses on estimation algorithms, sensors, and controllers for smart and autonomous systems, which is crucial for developing robots suitable for real-world farms.

Under his guidance, a highly qualified engineering researcher will lead robot development and oversee field deployment to improve sustainable land use.

Organization: U of MN - College of Design

Organization Description:
The University of Minnesota College of Design (CDES) conducts innovative research and across product design, human factors and ergonomics, user experience, the built and natural environment. CDES partners closely with community to co-design solutions that strengthen rural and agricultural communities and food systems; advance human-centered health care, health equity, and innovation; and make our built and natural environments more resilient.

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%	0.63		$107,000
Co-Project Manager Rajamani		To lead robot development			26.7%	0.12		$49,000
Postdoc		To work intensively on robot development			20.5%	2		$176,000
Grad Research Assistant		To support participatory design, data collection, prototype, and evaluation			46%	1.26		$141,000
							Sub Total	**$473,000**
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, drawing tools, colored paper, fabric	Materials for participatory design session with farmers					$1,000
							Sub Total	**$1,000**
Capital Expenditures								
		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 instrumented with wheel encoders,	X				$50,000

			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	50 trips, approx 70 miles per trip at 70 cents per mile	To visit farms during field deployment for data collection					$2,500
							Sub Total	**$2,500**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	~6 conferences (2/year @ $1750/trip)	To present research project findings.	X				$11,000
							Sub Total	**$11,000**
Printing and Publication								
	Publication	(4) open access publications ($750/publication)	To disseminate findings in top-tier peer review and relevant trade journals					$3,000
							Sub Total	**$3,000**

Other Expenses								
		Research Subject Payments	To compensate farmers and farm staff for their time and participation in data collection activities					$3,500
		Transcription	To transcribe interview research data for qualitative assessment					$5,000
		Participant Refreshments	Food and beverage for working lunches in co-design sessions (Phase 1) and interviews (Phase 3) with farmers.	X				$1,000
							Sub Total	**$9,500**
							Grand Total	**$562,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		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	~6 conferences (2/year @ $1750/trip)	While some conferences will be in the state of MN, we anticipate that findings will be disseminated at conferences outside the state.
Other Expenses		Participant Refreshments	We are seeking to support a working lunch for subjects who participate in co-design sessions and subject interviews. We will be conducting interviews on site and interview times may overlap with meal/break times.

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: $812,000

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
UMN Sponsored Projects Admin Authorization	d0127e68-ef9.pdf
Support Letter from Hmong American Farmers Association	fa77bf89-d88.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

Not acknowledged

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?

Yes

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 proposal:

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