Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID: 109-E**

Zero-Waste Aquaponic System for Fish and Vegetable Production

Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 906,400

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

We will develop and demonstrate a sustainable fish and vegetable production system utilizing food and other organic wastes to clean water by reducing landfill and sequester CO2 by growing vegetables.

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Sponsoring Organization: U of MN

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Web Address

Location

Region: Statewide

County Name: Statewide, Ramsey

City / Township:

Alternate Text for Visual:

Technical concept with process flow, input, output, and environmental issued to be addressed

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage		_____ TOTAL

PROJECT TITLE: Zero-waste aquaponic system for fish and vegetable production

I. PROJECT STATEMENT

Food production and consumption is considered to be one of the main causes of pressure on the environment. Furthermore, food waste management and recycling is one of the major issues faced by sustainable food production and consumption. Food wastes are composed of raw or cooked food materials generated at different stages of production, processing, retailing, and consumption. ***Disposal of food wastes is not only a costly operation, but also causes water pollution and CO_2 emission***. We are proposing a project to develop ***an ecologically engineered aquaponic system*** for local production of fish and organic vegetables. Such a ***zero-waste and water-saving system will effectively utilize food wastes, reduce disposal impacts on environment***, generate revenue, and create jobs.

We propose a closed-loop aquaponic system, in which the main input is food waste; water will be cleaned by algae and vegetable and recycled; wastes excreted by the fish will feed the algae and vegetables which also sequester CO_2.

While raising fish, cultivating algae and growing vegetable independently in aquatic environment are commonly practiced, integrating these in a closed-loop system requires additional knowledge that must be acquired through research and development. The proposed technology is aimed for small communities and farming families in Minnesota who have expressed strong interests in producing foods locally. This practice will effectively promote ***sustainable local and regional farming and food systems, reduce environmental impacts through reducing transportation associated with crop production, distribution, and consumption*** while providing healthy organic foods, jobs and educational opportunities for interested youths and community members. ***Financial interests as a result of the project will be shared with LCCMR.***

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: *Develop closed-loop aquaponic processes and demo facility for zero-waste crop production* **Budget: $650,000**

We will develop and demonstrate processes and a system for integrated production of fish and vegetables using food wastes, which help reduce landfill to clean water and sequester CO_2 to reduce greenhouse gas. Specifically, we will:

(1) develop and optimize process parameters for individual components (fish, vegetable, algae, and water treatment) for best compatibility, yields, and quality;
(2) formulate fish feeds with different nutrient profiles by mixing sorted protein, carbohydrate, and oil fractions of food wastes, harvested algal biomass, vegetable scraps, and other organic wastes;
(3) develop a closed-loop aquaponic facility for demonstration.

Outcome/task	Completion Date
1. Develop and optimize process parameters for best compatibility, yields, and quality	*12/31/2016*
2. Design the closed-loop aquaponic demo system	*03/31/2017*
3. Construct the system	*12/31/2018*
4. Test and improve the system	06/30/2018

Activity 2: *Evaluation of sustainability, demonstration, and outreach* **Budget: $256,400**

We will evaluate and demonstrate the systems and present our results to the general public, in scientific and trade journals, and to funding agencies. Specifically, we will:

(1) evaluate the systems against designed technical specifications;

(2) evaluate and quantify the green impacts and benefits with respect to reduction in water use and emission, carbon sequestration, energy balance, and food yields and quality, and conduct economic and environmental life-cycle analysis;

(3) demonstrate the systems and processes to stakeholders; and
(4) present the project data to funding agencies, academic community, and the general public through reports, seminars, meetings, and journal publications.

Outcome	Completion Date
1. Collect evaluation data	03/31/2018
2. Conduct environmental, techno-economic, and societal impact evaluation	06/30/2018
3. Demonstrations and outreach	06/30/2018
4. Project report and presentations	09/30/2018

III. PROJECT STRATEGY

A. Project Team/Partners:

UMN investigators

Dr. Dean Current, Program Director, Center for Integrated Natural Resources and Agricultural Management, UMN, will be the PI and PD, responsible for overall project planning and management and for conducting the economic and life-cycle analysis.

Dr. Paul Chen, Associate Research Professor, Program Director, Center for Biorefining, Dept of BBE, UMN, will be a co-PI. He will be responsible for process development and optimization

Dr. Roger Ruan, Professor, Director, Center for Biorefining, Department of Bioproducts and Biosystems Engineering (BBE), UMN, will be a co-PI, responsible for development, design and evaluation of the closed-loop aquaponic demonstration facility.

Dr. Petrona Lee, Environment and Health Sciences, UMN, will be a co-PI, responsible for food waste to fish feed related work, demonstration, and outreach.

Dr. Hans R. Giselrod, Professor, Dept. of Plant and Environmental Sciences, University of Life Sciences, As, Norway, will be a collaborator, responsible for algae based fish feed development and evaluation (he will receive no funding).

Richard A. (Dick) Hemmingsen, Senior Fellow, Dept of BBE, UMN, will be a co-PI, coordinating demonstration and outreach.

Partner

We have identified a local farmer, who has expressed interest in collaborating with our research team to provide insights from his experiences with aquaponic farming. Mr. Tim Page is an ideal community representative who has extensive community involvement in exposing disadvantaged youths to various agricultural related strategies. He is responsible for initiating farm markets and working with churches in the area as well as the Healthy Foods Healthy Lives Institute at the University of Minnesota. Mr. Page has expressed great interest in being the main point of contact in bringing the finished product to the community. His website, http://www.holistichealthfarms.com/education.html, provides good testament to his zeal and commitment to farming enterprises youth education and community involvement. He will receive no funding.

B. Timeline Requirements: This is a three-year project. The first two years will be devoted to design and construction; the third for testing and demonstration and additional data which will be important for R & D and eventual technology transfer. An educational outreach and communication strategy will be developed throughout the project

C. Long-Term Strategy and Future Funding Needs:

The proposed project, built on our existing R & D efforts, does not need additional investment other than the requested financial support to complete. However, further R & D leading to eventual technology transfer and commercialization will be our long-term goal and will require additional funding. Next level scale-up pilot facilities must be demonstrated with federal, state, and private funding before the technology can be commercialized.

2015 Detailed Project Budget

Project Title: Zzero waste aquaponic system for fish and vegetable production

IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM	AMOUNT
Personnel:	$ 619,000
Dean Current, PI, 0.08 FTE, (75% salary/25% fringe) - $20,700;	
Roger Ruan, Co-PI, 0.05 FTE, (75% salary/25% fringe) - $25,610;	
Paul Chen, co-PI, 0.10 FTE (75% salary/25% fringe) - $34,240;	
Petrona Lee, Co-Pi, 0.07 FTE, (75% salary/25% fringe) - $41,400;	
Richard Hemmingsen, Co-PI, 0.05 FTE, (75% salary/25% fringe) - $32,330;	
Research Associate (Ruan and Chen), 1 FTE, (75% salary/25% fringe) - $165,550;	
Post-doc Associate (Lee) 0.25 FTE (82% salary/ 18% fringe) - $37,560;	
2 Grad Research Asst (Current and Ruan/Chen), 1 FTE,(57% salary52% fringe) $261,610	
Equipment/Tools/Supplies:	
Supplies: Fish feed supplements , Chemical reagents and supplies for analysis monitoring of fish feed, water, nutrients, components for creating bench experiment system for fish culture (some of the components will be reused in the demo facility), components for creating bench scale hydroponic apparatus for vegetable cultivation, components for creating bench scale photobioreactor for algae culture, Small scale photovoltaic power generator to supply electricity for pumping and mixing (Some of components will be reused in demo facility), Dissolved oxygen analyzer, Dual input Thermocouple Thermometer (5), Analytical instrument maintenance	77,300
Printing brochures and posters for outreach and demonstration activities	900
Fish feed processing equipment components for drying, grinding, and pelletizing	30,000
Demo facility: Fish tank components including tank, pumps, hoses	20,000
Demo-facility: Photobioreactor components including trays, solar panel, mixing, pumps, frame	40,000
Demo facility: Hydroponic components including trays, frames, piping, pumps, plant holding	60,000
Demo facility: Ozone based water treatment system to disinfect water for vegetable growing	10,000
Demo facility: Greenhouse (25 X 50 ft) with heating	40,000
Travel: for researchers to travel between campus and development/demonstration site and outreach	$ 9,200
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 906,400

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	N/A	*Indicate: Secured or Pending*
Other State $ To Be Applied To Project During Project Period:	N/A	*Indicate: Secured or Pending*
In-kind Services To Be Applied To Project During Project Period: *Unrecovered Facilities and Administrative (F&A, indirect costs)*	$ 415,000	*Indicate: Secured or Pending*
Funding History:		
Pyrolysis pilot project (ML 2007)	$ 500,000	spent
Algae for Fuels Pilot Project (ML 2010)	$ 900,000	spent
Remaining $ From Current ENRTF Appropriation:		
Demonstrating innovative technologies to fully utilize wastewater resources (ML2014)	$ 1,000,000	*pending*

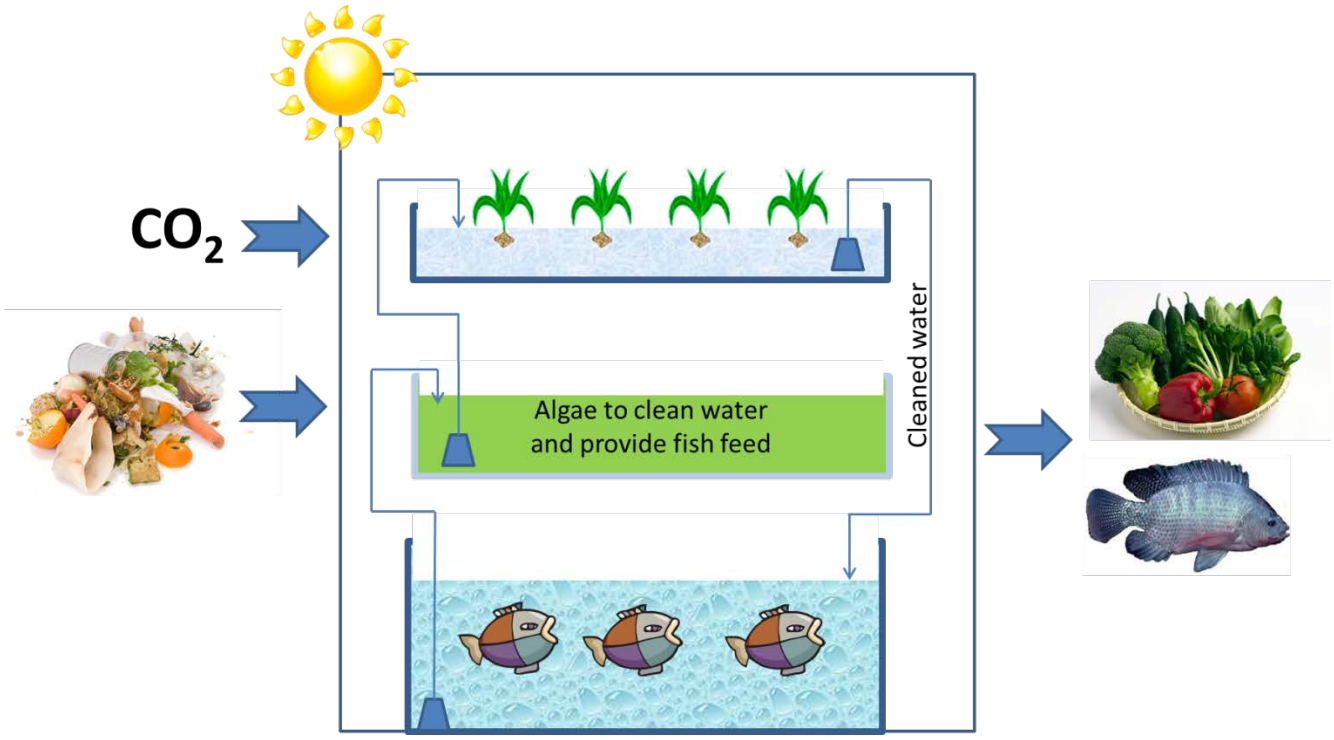

Figure 1. A closed-loop aquaponic system for sustainable production of fish and vegetables, cleaning water and sequestering CO_2.

Figure 2. Food waste landfill causing environment problems.

Project Manager Qualifications and Organization Description

Dr. Dean Current is the Program Director of Center for Integrated Natural Resources and Agricultural Management (CINRAM) at UMN. CINRAM is a partner-based organization that catalyzes the development and adoption of integrated land use systems. CINRAM links the expertise of the University of Minnesota with the experience and insights of people and organizations who work with, and have an understanding of, opportunities and issues across the landscape. CINRAM is an interdisciplinary center that works across disciplines in the College of Food Agriculture and Natural Resource Sciences as well as other colleges across the University as needed while working closely with outstate and non-university partners.

Dr. Current focuses his research on community based natural resource management, community forestry, agroforestry, market based conservation, economic and environmental impact assessment, multifunctional agriculture, payments for environmental/ecosystem services, and biomass energy options. He manages a portfolio of interdisciplinary projects involving University researchers, local watershed groups, state and federal agency representatives as well as international researchers and organizations dealing with biomass energy production and processing, carbon sequestration, market-based approaches to integrated watershed management for environmental and economic benefits as well as market based approaches to forest and ecosystem conservation. He also serves as a consultant for many companies/organizations. The current research project deals with sustainable production systems, community organization and using markets to support sustainable production systems, areas where Dr. Current continues to work.

Dr. Current was a co-PI for an LCCMR sponsored project titled “Algae for Fuels Pilot Project” led by Dr. Roger Ruan. He also collaborated with Drs. Roger Ruan and Paul Chen on DOE Biomass R&D project titled “Development of Scalable Biorefining Processes for Distributed Biomass Conversion”. The three collaborating UMN departments offer unique and complementing expertise and experience which will ensure that the proposed work will be properly carried out and the set of objectives will be successfully delivered.