Awardee Organization University of Florida

1. DUNS
2. EIN

Program Announcement NSF 17-530

NSF Unit of Consideration Directorate for Engineering

Title Multi-scale Rangeland Management Decision Support System

Budget

Duration 2 years

PI Joaquin Casanova

International Activities Country Names Niger

Project Summary

Overview

1 Intellectual Merit

2 Broader Impact

The Sahel region of Africa, a ecosystem south of the Sahara comprised of primarily savannah [5], is suffering from a mix of severe problems, ultimately affecting human well-being, local ecosystem health, and global climate. Prolonged drought in the region has led to declines in food production; when combined with overgrazing this has resulted in soil erosion can result from excessive patch grazing [3]; this reduces the soil's ability to support vegetation when rains do arrive. Traditionally, in the Sahel region, herders were nomadic or semi-nomadic, bringing their herds to the north during the brief wet season, and south to the Niger Delta in the dry season [3]. Now, there is intense competition for grazing in the relatively wet Niger Delta between these semi-nomads and sedentary farmers in the Delta. Ultimately, this region is suffering from the tragedy of the commons, where public resources are used until depletion. Greater coordination is needed between farmers and herders to avoid this problem [1], and greater understanding of the interactions between human decision making, agroecosystem dynamics, and the available cyberinfrastructure for monitoring. The proposed research aims to provide farmers and herders a technological way to manage the grazing resources of the Sahel and avoid the tragedy of the commons.

To help solve this resource management issue, this research proposes developing, testing, and implementing a decision support system which can guide grazing patterns for farmers and herders for optimal economic and environmental outcomes. Similar software has been developed for northern Ethiopia [4]. By feeding multispectral data from wireless sensors, GPS tracking of livestock, and satellite data, into models for flora, fauna, climate, and economics, any individual could predict the outcomes of their farming/grazing actions.

Livestock are selective in what they graze on. Cattle's protein requirements vary over the year so grazing patterns show important patterns at small and large scales as they choose grass species higher in nitrogen [3]. Addtionally, topographic features, such as water, lead cattle to congregate and overgraze. Thus, sensors should be capabale of relaying grazing patterns and metrics of plant health and diversity on both scales. UAVs with computer vision, to identify plant species and density, and GPS cattle tracking, for monitoring grazing [7], can handle the small scale variations. Additional local measurements could include microwave sensing of soil water and local weather stations. Satellite data (in visible and near-infrared) has been used to assess the health of rangelands in terms of vegetation health and nutritional content on large scales [6]. Sticking to simple sensors mounted on cattle and drones, and already available satellite data, provides data cheaply and effectively in an economically-stressed region. Feeding this data into vegetation/animal/economic models, similar to SPUR [2], or soft computing techniques like genetic programming, can provide predictions for the courses of action which optimally benefit individuals and the ecological health of the region. Such software would be implemented in a smartphone app, as smartphone adoption is high in this region of Africa.

Intellectual Merit

Broader Impacts

Table of Contents

3 Introduction: Dynamics of the Sahel Region

4 Background and Overview

5 Intellectual Merit and Broader Impact

6 Framework for Investigation

7 Summary

7.1 Principle Research Issues

7.2 Research Outcomes

References Cited

[1] Henk Breman and CT De Wit. Rangeland productivity and exploitation in the Sahel. *Science*, 221(303):1341–1347, 1983.

[2] DH Carlson and TL Thurow. Comprehensive evaluation of the improved SPUR model (SPUR-91). *Ecological Modelling*, 85(2-3):229–240, 1996.

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[4] Massimo Dragan, Enrico Feoli, Michele Fernetti, and Woldu Zerihun. Application of a spatial decision support system (SDSS) to reduce soil erosion in northern Ethiopia. *Environmental Modelling & Software*, 18(10):861–868, 2003.

[5] World Wildlife Fund. Sahelian acacia savanna, Accessed January 30, 2017.

[6] Nichola M Knox, Andrew K Skidmore, Herbert HT Prins, Ignas MA Heitkönig, Rob Slotow, Cornelis van der Waal, and William F de Boer. Remote sensing of forage nutrients: Combining ecological and spectral absorption feature data. *ISPRS Journal of Photogrammetry and Remote Sensing*, 72:27–35, 2012.

[7] Tim Wark, Peter Corke, Pavan Sikka, Lasse Klingbeil, Ying Guo, Chris Crossman, Phil Valencia, Dave Swain, and Greg Bishop-Hurley. Transforming agriculture through pervasive wireless sensor networks. *IEEE Pervasive Computing*, 6(2), 2007.

Budget Justification

8 Personnel

9 Fringe Benefits

10 Materials

11 Travel

12 Publication

Biographical Sketch: Joaquin Casanova

(a) Professional Preparation

Phd, Electrical Engineering University of Florida, Gainesville, FL, May 2010

ME, Agricultural and Biological Engineering University of Florida, Gainesville, FL, December 2007

BS, Agricultural and Biological Engineering University of Florida, Gainesville, FL, December 2006

(b) Appointments

Research Assistant Professor, University of Florida, August 2016

Senior Engineer, University of Florida, November 2013

Research Engineer, USDA, May 2010

(c) Products

30 technical publications in peer-reviewed journals and conference proceedings. 2 patents awarded. Most closely related to the proposed project:

1. Schwartz, R. C., **Casanova, J. J.**, Bell, J. M., & Evett, S. R. (2014). A reevaluation of time domain reflectometry propagation time determination in soils. Vadose Zone Journal, 13(1).

2. **Casanova, J. J.**, Schwartz, R. C., & Evett, S. R. (2014). Design and field tests of a directly coupled waveguide-on-access-tube soil water sensor.Applied Engineering in Agriculture, 30(1), 105-112.

3. **Casanova, J. J.**, O'Shaughnessy, S. A., Evett, S. R., & Rush, C. M. (2014). Development of a wireless computer vision instrument to detect biotic stress in wheat. Sensors, 14(9), 17753-17769.

4. **Casanova, J. J.**, OShaughnessy, S., & Evett, S. (2013, November). Wireless computer vision system for crop stress detection. In ASA-CSSA-SSSA Annual Meeting Abstracts (p. 123). ASA-CSSA-SSSA Annual Meeting Abstracts. Session 196-7.

5. **Casanova, J. J.**, Evett, S. R., & Schwartz, R. C. (2012). Design and field tests of an access-tube soil water sensor. Applied Engineering in Agriculture,28(4), 603-610.

6. **Casanova, J. J.**, Evett, S. R., & Schwartz, R. C. (2012). Design of access-tube TDR sensor for soil water content: Testing. Sensors Journal, IEEE,12(6), 2064-2070.

7. **Casanova, J. J.**, Evett, S. R., & Schwartz, R. C. (2012). Design of access-tube TDR sensor for soil water content: Theory. Sensors Journal, IEEE,12(6), 1979-1986.

8. Garnica, J., **Casanova, J. J.**, & Lin, J. (2011, May). High efficiency midrange wireless power transfer system. In Microwave Workshop Series on Innovative Wireless Power Transmission: Technologies, Systems, and Applications (IMWS), 2011 IEEE MTT-S International (pp. 73-76). IEEE.

9. **Casanova, J. J.**, Taylor, J. A., & Lin, J. (2010). Design of a 3-D fractal heatsink antenna. Antennas and Wireless Propagation Letters, IEEE, 9, 1061-1064.

10. Low, Z. N., **Casanova, J. J.**, Maier, P. H., Taylor, J. A., Chinga, R. A., & Lin, J. (2010). Method of load/fault detection for loosely coupled planar wireless power transfer system with power delivery tracking. Industrial Electronics, IEEE Transactions on, 57(4), 1478-1486.

11. **Casanova, J. J.**, Low, Z. N., & Lin, J. (2009). Design and optimization of a class-E amplifier for a loosely coupled planar wireless power system.Circuits and Systems II: Express Briefs, IEEE Transactions on, 56(11), 830-834.

12. **Casanova, J. J.**, Low, Z. N., & Lin, J. (2009). A loosely coupled planar wireless power system for multiple receivers. Industrial Electronics, IEEE Transactions on, 56(8), 3060-3068.

13. **Casanova, J. J.**, Judge, J., & Jang, M. (2007). Modeling transmission of microwaves through dynamic vegetation. Geoscience and Remote Sensing, IEEE Transactions on, 45(10), 3145-3149.

(d) Synergistic Activities

1. **Main Activities** Dr. Casanova is a research assistant professor in the Department of Electrical and Computer Engineering at the University of Florida. His main research activities are electromagnetic sensors, instrumentation design, and machine intelligence applications. Previously he did research with the USDA in these areas and developed chemistry instrumentation for UFs Chemistry Department.

2. **Professional Membership**

   - 2004-present Member American Society of Agricultural and Biological Engineers (ASABE)
   - 2006-present Member Institute of Electrical and Electronics Engineers (IEEE)

Data Management Plan

13 Basic Information

14 Categories of Data and Standards for Format and Metadata

14.1 Raw Data Used Towards Publication

14.2 Analyzed Data Used Towards Publications

14.3 Data Not Used Towards Publications

15 Access to Data

16 Archiving and Preservation

17 Plans for Transition or Termination of Data Collection

Collaborators and Other Affiliations Information

Collaborators and Co-Editors

Graduate Advisors and Postdoctoral Sponsors

Thesis Advisor and Postgraduate Scholar Sponsor