U.S. India Agricultural Knowledge Initiative

Title: Sustainable Water Resource Management: U.S - India Collaborative Research and Education

Focus Area: Water Resource Management

Principal Investigator: W. D. Graham
Carl S. Swisher Chair in Water Resources, Director University of Florida Water Institute
PO Box 110570, University of Florida, Gainesville Florida 32611-0570
Phone: 352-392-1864 x285; Fax: 352-392-4092
Email: wgraham@ufl.edu

Co-Principal Investigators:
K. Ramesh Reddy, Graduate Research Professor and Chair, Soil and Water Science Department
University of Florida (UF)-Institute of Food and Agricultural Sciences (IFAS), 106 Newell Hall,
P.O. Box 110510, Gainesville, FL 32611-0510.
E-mail: krr@ifas.ufl.edu

Kenneth L Campbell, Professor and Chair, Agricultural and Biological Engineering
Department, University of Florida (UF)-Institute of Food and Agricultural Sciences (IFAS), 120
Rogers Hall, PO Box 110570, Gainesville, FL 32611-0570.
E-mail: klc@ufl.edu

Liiset M. Staal, Assistant Director, International Programs,
University of Florida-IFAS, 2039 McCarty Hall, PO Box 110282
Gainesville, FL 32611-0570
Email: lstaal@ufl.edu

Collaborators in the U.S.
North Carolina A & T University
G.B. Reddy, Professor/Chairman, Department of Natural Resources and Environmental
Design, North Carolina Agricultural & Technical State University
Email: reddyg@ncat.edu

Collaborators from India
Acharya N. G. Ranga Agricultural University
M. Devender Reddy, Principal Scientist (Agronomy), Water Technology Centre, PGR Centre,
Acharya N.G.Ranga Agricultural University, Rajendranagar, Hyderabad – 500030
Email: metukudreddy@rediffmail.com

Punjab Agricultural University
B.S. Dhillon, Director of Research, Punjab Agricultural University,
Ludhiana – 141 004 India
Email: drpau@pau.edu.
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3 Abstract

The overall goal of this project is to enhance water resource management in India through collaborative research and education activities between the University of Florida (UF) and North Carolina Agricultural and Technical State University (NCA&T) in the US, and Acharya N. G. Ranga Agricultural University (ANGRAU) and Punjab Agricultural University (PAU) in India. Specific areas of water resource management that will be addressed include: 1) Sustainable Use of Water Resources, 2) Water Quality Management and Remediation, 3) Use of Simulation Models in Water Resource-Agricultural-Ecosystem Management, 4) Improved Water Use Efficiency and Drought Management. Project goals will be accomplished through the following activities:

- Joint workshops held at ANGRAU and PAU to identify and prioritize water resource research and education areas of common interest and concern,
- Hosting of sabbaticals of Indian scientists at both UF and NCA&T to develop joint proposals to address the priority research and education areas,
- Graduate Research Assistantships for 6 Indian students to obtain graduate degrees at UF and NCA&T in priority research and education areas under the joint supervision of UF and Indian Faculty members.

The proposed workshops, sabbaticals and graduate education activities are designed as tools to build long-term relationships and research programs between UF, NCA&T, ANGRAU, and PAU. The research programs will be sustained by the additional extramural funding obtained as a result of this project, as well as the professional relationships forged during the co-advising and mentoring of Indian graduate students.
4.0 Project Description

4.1 Introduction and rationale

Over the last four decades collaboration between U.S., Land Grant Universities and India’s National Agricultural Research System has helped usher in India’s green revolution and has led to India’s increased self-reliance in food security. However new issues such as water resource depletion and degradation, global warming and climate change, as well as continuing increases in population growth pose new challenges to India’s agricultural system. To address these new challenges the U.S.–India Agricultural Knowledge Initiative (AKI) has been jointly undertaken by the U.S. Department of Agriculture (USDA) and the Indian Council of Agricultural Research (ICAR). One of the four major thrust areas of the AKI is research and training in the sustainable use, conservation, and protection of water resources.

Increased population, rapid urban development, large agricultural water demands, and the need to protect natural resources have led to water resource problems in many parts of India. The total demand for fresh water in India was estimated to 634 billion cubic meters (bcm) in the year 2000 (approximately 460 billions of gallons per day (bgd)) and is estimated to be 1447 bcm in the year 2050 (approximately 1050 bgd). The vast majority of water currently used in India is for agriculture (approximately 80%), and irrigation efficiencies are extremely low (from 17% to 48%). Furthermore rapid industrialization and urbanization have also led to increased demand for public water supply, industrial use and thermal power. These competing sectors all use good quality fresh water and have the potential to release poor quality waters into the natural system. Uneven spatial and temporal distribution of rainfall, and the likelihood of rainfall redistribution due to climate change, exacerbates problems associated with floods, droughts, soil erosion, poor nutrient use efficiency by crops, and nutrient leaching.
Similar problems of increasing population, rapid urban development, large agricultural water demands, and the need to protect natural resources exist in many parts of the Southeastern United States. For example, due to the rapidly increasing population, freshwater withdrawals in the state of Florida alone are expected to grow from approximately 8.2 billion gallons per day (bgd) in 2000 to more than 9.3 bgd in 2020, with the obvious potential to produce significant conflict between urban, agricultural, industrial, and natural system water users. Like in India, agriculture currently constitutes the majority Florida’s current freshwater usage, but public water supply needs are growing rapidly and likely to surpass agriculture water needs in the near future. In recognition of these problems, proactive state and national research and education programs have been enacted in the US to promote water conservation; development of alternative water supplies (for example wastewater reuse, desalination, aquifer storage and recovery); establishment of minimum flows and levels (MFLs) to protect and conserve surface and groundwater resources; and establishment of total maximum daily loads (TMDLs) to protect water bodies from contamination and subsequent ecological decline. Taking advantage of lessons learned in the US over the past several decades should help India develop solutions to its own water resource problems. Furthermore, pooling the talents of both Indian and American scientists, and focusing multidisciplinary and multinational intellect on common problems, should help both countries make significant improvements in their water resource management strategies.

4.2 Project goals and objectives

The overall goal of this project is to enhance water resource management in India through collaborative research and education activities between the University of Florida (UF) and North Carolina Agricultural and Technical State University (NCA&T) in the US, and Acharya N. G.
Ranga Agricultural University (ANGRAU) and Punjab Agricultural University (PAU) in India. Specific areas of water resource management that will be addressed in this proposal include: 1) Sustainable Use of Water Resources, 2) Water Quality Management and Remediation, 3) Use of Simulation Models in Water Resource-Agricultural-Ecosystem Management, 4) Improved Water and Nutrient Use Efficiency and Drought Management.

Project goals will be accomplished through the following activities:

- Joint workshops held at ANGRAU and PAU to identify and prioritize water resource research and education areas of mutual interest and concern, and develop a plan of work,
- Hosting of sabbaticals of Indian scientists at both UF and NCA&T to develop joint proposals to address the priority research and education areas,
- Graduate Research Assistantships for Indian students to obtain graduate degrees at UF and NCA&T in priority research and education areas under the joint supervision of UF and Indian Faculty members.

University of Florida already has signed cooperative agreements with both ANGRAU and PAU which will facilitate the exchange of students and faculty and the conduct of joint research projects.

4.3 Project plan


Three day workshops at both ANGRAU and PAU will be held to present UF and NCA&T experience and expertise, learn about local needs and expertise, and investigate collaborative research and education opportunities in the following areas pertinent to water resource management: 1) Sustainable Use of Water Resources, 2) Water Quality Management and Remediation, 3) Use of Simulation Models in Water Resource-Agricultural-Ecosystem
Management, 4) Improved Water Use Efficiency and Drought Management. During the workshops each institution will present recent case studies and on-going research programs that illustrate experience and expertise in each of the focus areas defined above. Example case studies and current research projects being conducted by US faculty that may be presented are included in the table below. Details of the US faculty experience and expertise can be found in Appendix A.

Table 1: US Case Studies and Research Expertise

<table>
<thead>
<tr>
<th>Sustainable use of Water Resources</th>
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<tbody>
<tr>
<td>• Aquifer management – Use of aquifer storage recovery and optimal groundwater pumping scenarios to minimize groundwater drawdown and saltwater intrusion (Graham)</td>
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<tr>
<td>• Use of surface tailwater recovery ponds to reduce groundwater pumping requirements for agricultural irrigation (Shukla)</td>
</tr>
<tr>
<td>• Wastewater reuse for landscape and agricultural irrigation (Haman)</td>
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<table>
<thead>
<tr>
<th>Water quality management and remediation</th>
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<tbody>
<tr>
<td>• Soil and Aquifer remediation (Jawitz, Li)</td>
</tr>
<tr>
<td>• Measuring subsurface contaminant source zone strength and prioritizing sites for monitoring and remediation (Jawitz)</td>
</tr>
<tr>
<td>• Integrated Nutrient management (Rao, Li)</td>
</tr>
<tr>
<td>• Development and assessment of best management practices to reduce non-point source pollution (Graham, Li, Shukla, Raczkowski, Rao, Reyes)</td>
</tr>
<tr>
<td>• Soil quality and link to water quality (Reddy, Reddy)</td>
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<tr>
<td>• Land application of non-hazardous wastes (Rao, Li)</td>
</tr>
<tr>
<td>• Constructed wetlands to improve water quality (Reddy, Reddy)</td>
</tr>
<tr>
<td>• Lake and reservoir management (Reddy)</td>
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<table>
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<tr>
<th>Use of Simulation Models in water resource-agricultural-ecosystem management</th>
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<tbody>
<tr>
<td>• Watershed modeling to simulate long-term effects of BMP adoption (Campbell, Reyes, Shukla)</td>
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<tr>
<td>• Simulation of cropping system response to soil, climate, irrigation and nutrient management strategies (Jones)</td>
</tr>
<tr>
<td>• Hydrologic and biogeochemical process models (Jawitz, Reddy)</td>
</tr>
<tr>
<td>• Application of climate forecasts to reduce risks associated with agricultural production (Jones)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Improved Water Use Efficiency and Drought Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Impact of climate change on droughts and identification of hot spots (Jones)</td>
</tr>
<tr>
<td>• Design and management of irrigation systems for improved water use efficiency (Haman, Shukla)</td>
</tr>
<tr>
<td>• Remote sensing of soil moisture for improved irrigation management (Judge, Jones, Graham)</td>
</tr>
<tr>
<td>• Nutrient and water use efficiency by crops (Rao and Li)</td>
</tr>
</tbody>
</table>

The outcome of these workshops will be the identification of the most promising areas for
collaborative research and the establishment of faculty partnerships for research and education activities. For each area of research identified a white paper outlining problem solving research plan for 3 to 5 years and funding opportunities in respective countries will be co-authored by Indian and US scientists.

**Task 2. Mini-Sabbaticals for Indian Faculty to visit UF and NCA&T**

Following the preparation of the white papers, Indian Faculty co-authors from AGNRAU and PAU will be funded to spend 2-3 months working with US faculty co-authors to discuss the details of the research plan and specific methodologies needed to conduct the proposed research. During the visit to the US, Indian scientists will also have the opportunity to participate in UF and NCA&T courses, and to visit state agencies in Florida and North Carolina involved in water management. Field trips in Florida includes: UF Research and Education Centers working on specific crops, Florida Everglades (where the world’s largest ecosystem restoration is being undertaken), the Tampa Bay Metropolitan Area (where the largest desalination plant in the US is currently being constructed), the Lake Okeechobee basin and the Suwannee River basin (where agricultural Best Management Practices (BMPs) are being developed and tested in order to comply Florida’s first TMDLs), the South West Florida Water Management District (where innovative irrigation and nutrient management practices are being developed and demonstrated) and St. Johns River Basin (where Minimum Flows and Levels are being established for water resource and ecosystem protection). Field trips in North Carolina include various experimental research sites and research centers. The product of these mini-sabbaticals will be a finalized research plan for 3 to 5 years with defined goals and products, to conduct research on a specific water resource problem solving issue that has immediate potential to improve Indian water resource management.
Task 3.  **Graduate Student Training and Education**

After research priorities are identified and the research work plans are written, the UF Water Institute and the College of Agricultural and Life Sciences will fully sponsor 4 Indian students to obtain graduate degrees at UF as Water Institute Graduate Fellows. Similarly NCA&T will sponsor 2 students to obtain graduate degrees at NCA&T. During the first year of their graduate studies these students will take courses at their US institutions and work with the US-Indian faculty partners to conduct the literature reviews and to gather the preliminary data necessary to prepare successful proposals for external funding. During the latter part of their graduate studies these students will return to India to conduct their field research. Students at both UF and NCA&T will have the option of continuing their graduate course work while conducting research in India via UF distance education courses (see [http://soils.ifas.ufl.edu/distance/courses.html](http://soils.ifas.ufl.edu/distance/courses.html) or [http://www.ees.ufl.edu/prospective/graduate/ufedge.asp](http://www.ees.ufl.edu/prospective/graduate/ufedge.asp) for distance education course offerings).

At UF the Water Institute Fellows will have the choice of enrolling in M.S. or Ph. D. graduate programs in the Soil and Water Science or Agricultural and Biological Engineering Departments, and will be required to participate in the Hydrologic Sciences Academic Cluster (for details see [http://hydrology.ufl.edu](http://hydrology.ufl.edu)). All Fellows will be formally co-advised by Faculty from the US and India. Research to be pursued by the graduate student Fellows will focus on water management issues related to establishing a sustainable partnership between urban, agricultural and natural ecosystems. To integrate research and education activities, the cohort of 6 graduate students will focus on issues associated with one or two particular watersheds in India,
using lessons learned from comparable issues and watersheds in the US. Through this common focus the graduate students will obtain a common, broad view of water quantity and quality issues, that involve multiple interfaces (i.e., soil water and groundwater; groundwater and surface water; soil water and surface water; soil water and plant roots, plant canopies and atmosphere) and a blend of lab experiments, field work, and computer analysis and modeling. Each student will conduct individual research within his/her own interest area, but which contributes to goals of the overall program. At UF M.S. students will receive graduate student assistantships for two years and Ph. D. students will receive graduate student assistantships for four years. The costs of research conducted at the field sites in India will be covered by collaborating Indian universities.

4.4 Institutional Strengths and Needs – U.S., Universities

4.4.1 University of Florida

The University of Florida’s Institute of Food and Agricultural Sciences (UF/IFAS) is a federal-state-county partnership dedicated to developing knowledge in agriculture, human and natural resources, and the life sciences, and enhancing and sustaining the quality of human life by making that information accessible (http://ifas.ufl.edu). While extending into every community of the state, UF/IFAS has developed an international reputation for its accomplishments in teaching, research and extension. Because of this mission and the diversity of Florida’s climate and agricultural commodities, IFAS has facilities located throughout Florida. The College of Agricultural and Life Sciences (CALS) within UF/IFAS offers 20 undergraduate majors and more than 53 areas of specialization; the college is an educational leader in the areas of food, agriculture, natural resources and life sciences as they relate to human resources, the environment and communities. Master’s and doctoral degrees are offered in every department
and school. The college has approximately 4,200 students, including more than 900 graduate students. Distance education, via interactive video conferencing, videotape and the World Wide Web, are also offered.

The UF/IFAS research mission is to invent, discover and develop knowledge to enhance the agriculture and natural resources of Florida. Over 500 faculty members pursue fundamental and applied research that furthers understanding of natural and human systems. Research is supported by state and federally appropriated funds and supplemented by grants and contracts. IFAS research expenditures in the 2003-04 year exceeded $64.2 million. The Florida Agricultural Experiment Station administers and supports research programs in UF/IFAS. The research program was created in 1887 by federal legislation known as the Hatch Act, a follow-up to the 1862 Morrill Act that established US land-grant universities. The research programs support approximately 350 full-time equivalent faculty members in 17 academic departments on UF’s Gainesville campus and at 13 research and education centers around the state. Approximately one-fourth of the faculty are members work in some area of water resource management in Florida’s ecosystems.

The University of Florida has recently established a campus-wide Water Institute to coordinate and manage interdisciplinary water-related research and education programs. Over 100 faculty from the Colleges of Agricultural and Life Sciences, Business, Design Construction and Planning, Engineering, Health and Human Performance, Law, and Liberal Arts and Sciences, are currently affiliated with the UF Water Institute. The Water Institute creates and fosters the cross-campus and external linkages among these diverse programs required to deliver valued research, education, and management solutions to Florida’s water-related problems.
Through the development of innovative, interdisciplinary solutions to Florida issues the Water Institute provides a model for the interdisciplinary solution of water resource issues across the US and around the World. For more information see http://www.waterinstitute.ufl.edu.

4.4.2 North Carolina A and T University

North Carolina Agricultural and Technical State University (A&T) is a learner-centered community that develops and preserves intellectual capital through interdisciplinary learning, discovery, engagement, and operational excellence. The university offers degree programs at the baccalaureate, master’s and doctoral levels with emphasis on agriculture, engineering, science, technology, literature and other academic areas. As a land-grant university, A&T has a historic mission to meet the needs of agriculture. The School of Agriculture and Environmental Sciences’ (SAES) mission is to provide opportunities for individuals from diverse backgrounds to achieve excellence, through intellectual and technological advancements, in the food, agricultural, environmental and life sciences that will cultivate and enhance their potential for global leadership, productivity and competitiveness. The SAES offers 12 undergraduate majors, five Master’s degrees, and is part of the interdisciplinary Ph.D. in Energy and the Environment.

The SAES’ agricultural research program (ARP) has six initiatives including: human and community development, biotechnology and biodiversity, water and soil quality, agromedicine, nutrition and food safety, small-scale agriculture, and international trade and development. ARP funds is part of the research act of 1977 to provide research funds to 1890 ‘Historically Black Colleges and Universities’ land grant institutions. SAES has been involved in water research for the past 40 years. The SAES is also linked with the NC-Water Resources Research Institute (NC-WRRI). NC-WRRI is a unit of the University of North Carolina system and
identifies and supports research needed to help solve water quality and water resources problems in North Carolina and the region. NC-WRRI’s mission is threefold: to identify the state's ever-changing research needs; to motivate and support research by qualified scientists, and to provide for technology transfer. For more information see [www.ncsu.edu/wrri](http://www.ncsu.edu/wrri)

### 4.5 Institutional Strengths and Needs– Indian Universities

#### 4.5.1 Acharya N. G. Ranga Agricultural University

Acharya N.G. Ranga Agricultural University (AGNRU, one of the earliest State Agricultural Universities, was established in the country in the year 1964, as a sequel to the recommendations of the Radha Krishnan Commission on University Education (1949) and the First (1955) and Second (1960) joint Indo-American teams appointed by the Government of India to study the status and future of agricultural education in the country. ANGRAU was to serve as a seat of learning and scholarship and also to shoulder a major responsibility for securing the economic development and improvement of the status of the rural people in the state of Andhra Pradesh through education, research and extension programs. Details about this university can be found at: [http://www.angrau.net/home.htm](http://www.angrau.net/home.htm)

ANGRAU has just created the **Water Technology Center** at the Hyderabad campus on July 1st, 2006, with a goal to integrate teaching, research and extension work related to water resources across the University. Close interaction with the UF Water Institute, and the NC-WRRI will be mutually beneficial as this entity is established.

#### 4.5.2 Punjab Agricultural University

The Punjab Agricultural University (PAU) was established in 1962 at Ludhiana on the pattern of land grant colleges of USA with integrated teaching, research, and extension
programs. It is committed to continue improvement in the productivity and profitability of agriculture and allied sectors through the achievement of the following goals: (1) to provide quality education in the areas of agriculture, veterinary science, agricultural engineering and allied fields, (2) to undertake basic applied and adaptive research to seek appropriate solutions to emerging problems in agriculture and develop relevant technologies to improve socio-economic conditions of the faring community, (3) to develop an effective mechanism for the transfer of technology to the farmers and agricultural organizations through different extension programs with a view to improve agricultural productivity and economic conditions of rural population, and (4) to develop appropriate technology for supporting the growth of agro-based industries. The College of Agriculture is a premier college within PAU with teaching, research and extension education programs in agriculture that serve the people of Punjab and the country. The College is committed to excellence, innovation and effectiveness in education, research and transfer of technology programs that are responsive to the needs of its constituents. The PAU offers excellent research, education, and extension programs on various topics related to efficient management of soil and water resources, as related to sustainable high crop yields, while protecting ground water and surface waters. Details of water resource programs can be found at: http://www.pau.edu/.
5.0 Project Time Frame and Sustainability (Project begin date September 1, 2006):

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<tr>
<th>Timeline</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
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<td><strong>Task 1. US-India Workshop</strong></td>
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<td>Workshop Planning</td>
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<td>Workshop Execution</td>
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<td>White Paper Preparation</td>
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<td><strong>Task 2. US Sabbaticals</strong></td>
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<tr>
<td>Sabbatical visits &amp; proposal preparation</td>
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<td><strong>Task 3. Graduate Student Training</strong></td>
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<td>Graduate Student Recruitment</td>
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<td>Graduate Student enrollment at US Institution</td>
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<tr>
<td>Graduate Student research in India</td>
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1 Timeline shown is for the completion of an MS degree. In the case of Ph. D. students the time in each country should be doubled.

Principal Investigators Graham (Director of the UF Water Institute), Staal (Associate Director of UF-IFAS International Programs), Reddy (Chair of UF Soil and Water Science Department) and Campbell (Chair of Agricultural and Biological Engineering Department) will co-manage the project including planning and executing the workshops and sabbaticals; coordinating with Indian partners; and recruiting, admitting and funding the graduate research assistants. US and Indian Faculty participants in listed in Appendices A and B will be responsible for presenting case studies and research projects at the workshops; writing white papers and extramural grant proposals to sustain the program; and advising the graduate students funded by UF and NCA&T.
The proposed workshops, sabbaticals and graduate education activities are designed as tools to build long-term relationships and research programs between UF, NCA&T, ANGRAU, and PAU. The research programs will be sustained by the additional extramural funding obtained as a result of this project, as well as the professional relationships forged during the co-advising and mentoring of Indian graduate students. Both the UF Water Institute and UF-IFAS International Programs Office are committed to the long term pursuit and continued support of international research and education partnerships with India.
Appendix A: US Faculty Participants

Kenneth L. Campbell, Professor and Chair, Agricultural and Biological Engineering Department, University of Florida. Expertise: hydrology of agricultural watersheds; agricultural water quality management; agricultural drainage and water management; and hydrologic/water quality modeling.

Wendy D Graham, Swisher Eminent Scholar in Water Resources, and Director of the Water Institute, University of Florida. Expertise: Subsurface flow and solute transport modeling; groundwater resources evaluation and remediation; evaluation of impacts of agricultural production on surface and groundwater quality; development of hydrologic indicators of ecosystem status; stochastic modeling.

Dorota Z. Haman, Professor of Agricultural and Biological Engineering and Extension specialist, University of Florida. Expertise: irrigated agricultural systems, irrigation design and management, water use efficiency, plant/water relationships, irrigation water quality, smallholder irrigation, extension education.

James W. Jawitz, Assistant Professor of Soil and Water Science, University of Florida. Expertise: Assessment and remediation of human impacts on hydrologic ecosystems. Emphases on groundwater contaminant transport, remediation of contaminated sites, and wetland hydrology.

James W. Jones, Distinguished Professor, Agricultural and Biological Engineering Department, University of Florida. Expertise: Modeling of crop growth and yield; simulation of cropping systems in response to climate, soil, and management; analysis of agricultural and ecological systems; climate impacts on cropping systems; soil carbon sequestration; application of climate forecasts to reduce risks; and assessment of climate change impacts on agricultural systems.

Yuncong Li, Associate Professor of Soil and Water Sciences and Extension specialist, University of Florida. Expertise: chemical analysis of water, soil and plants; monitoring technology for surface and groundwater including flow proportional sampling; soil and water chemistry; nutrient cycling; ecosystem restoration; tropical agriculture.

Rao Mylavarapu, Associate Professor and Extension Soils Specialist, Soil & Water Science Department, University of Florida. Expertise: soil, nutrient, waste and water management for optimum economic crop production and sustainable environment; soil, plant and water testing, interpretations, nutrient recommendations; diffuse non-point pollution and water quality. Dr. Mylavarapu worked with several Indian scientists and has experience in Indian agricultural systems, especially in integrated nutrient management and soil fertility.

Manuel Reyes, Associate Professor, Bioenvironmental Engineering Program, Department of Natural Resources and Environmental Design, North Carolina Agricultural & Technical State University. Expertise: Watershed modeling and soil erosion and conservation

G. B. Reddy, Professor and Chairman, Department of Natural Resources and Environmental Design, North Carolina Agricultural & Technical State University. Expertise: Swine wastewater treatment using constructed wetlands, dynamics of nutrients and herbicides losses from different tillage practices, bioremediation of recalcitrant using white-rot fungi, nitrogen transformations in aquatic and cropping systems and remediation of herbicides in constructed wetlands

K. Ramesh Reddy, Graduate Research Professor and Chair of Soil and Water Science Department, University of Florida: Expertise: Soil and water quality, submerged soils, paddy soils, biogeochemistry, water reuse, treatment of drainage effluents using constructed wetlands, and lake and reservoir management. Dr. Reddy worked with several Indian scientists and has experience in Indian agricultural systems, especially in crops such as rice.

Sanjay Shukla, Assistant Professor of Agricultural and Biological Engineering and Water Resources specialist, University of Florida. Expertise: Water quantity/quality monitoring and modeling, evaluation of Best Management Practices (BMPs); watershed hydrology; agricultural stormwater management; and irrigation and drainage.
Appendix B: Indian Faculty Participants

[Potential partners from Punjab Agricultural University will be identified through the Director of Research]

INTEGRATED NUTRIENT MANAGEMENT

1. Dr. A. Sreenivas Raju, Professor & Univ. Head, College of Agriculture, ANGRAU.
   E-mail: sr_akam@yahoo.co.in

IRRIGATION WATER MANAGEMENT

1. Dr. M. Devender Reddy, Principal Scientist (Agronomy), WTC, ANGRAU,
   E-Mail: metukudreddy@rediffmail.com

2. Dr. T.V. Satyanarayana, Principal Scientist, (Soil & Water Engg.) APWAMP, ANGRAU, Bapatla.
   E-Mail: tvsatyanarayana@hotmail.com

CROP MODELING

1. Dr. T. Yellamanda Reddy, Assoc. Director of Research, RARS Nandyal., ANGRAU.
   E-Mail: adr_rarsnandyal@rediffmail.com

2. Dr. D. Raji Reddy, Principal Scientist (Agromet), Agromet Unit ARI, R'nagar, ANGRAU.
   E-Mail: drreddy001@yahoo.co.in

3. Dr. B.S. Dhillon, Director of Research, Punjab Agricultural University.
   Email: drpau@pau.edu, telephone No. 91-161-2401221.

WATER QUALITY

1. Dr. T. Jeevan Rao, Assoc. Professor Dept. of Environmental Sciences, College of Agriculture, ANGRAU, R'nagar.
   E-Mail: raojeevan@yahoo.com

2. Dr. Prabhu Prasadini, Assoc. Professor Dept. of Environmental Sciences, College of Agriculture, ANGRAU, R'nagar.
   E-Mail: prabhuprasadini@rediffmail.com