Applicant: **Kumar, Swagat**
Organisation: **Edge Hill University**
Funding Sought: **£224,747.00**

ICA\R1\201047

iRice: Intelligent Platform for Real-time Rice Crop Monitoring and Management

This project aims at developing a digital platform for making information readily available and accessible to farmers in Indian villages at an affordable cost. Lack of access to expert knowledge is identified as one of the key reasons for low agricultural productivity in India as farmers don’t follow best agricultural practices or find it difficult to detect crop diseases early and take necessary remedial actions in time. Crop diseases are responsible for about 10-15% of annual losses globally including India. In the absence of adequate information, farmers use pesticides and fertilizers indiscriminately, leading to higher cultivation costs and environmental and food pollution. Increased cultivation costs and risks of crop failure is considered as a leading cause of rural-to-urban migration of male labourers, leading to increased feminisation of Indian agriculture where the women are now left with the dual burden of managing household along with farm cultivation without any tangible increase in household income. The proposed data-driven platform will address the pressing need and enable the farmers to carry out real-time and on-demand monitoring of crops and seek expert guidance throughout the crop cultivation cycle at an affordable cost. Novel research contributions will be made in the area of image-based crop disease detection and prediction and, developing novel architectures for effective data collection from fields. The efficacy of the proposed platform will be demonstrated through a real-world pilot experiment involving farmers. The research outcomes and annotated datasets will be published through public engagement events, international conferences and journals and project websites.

COLLABORATOR DETAILS

Title	Dr
Name	Swagat
Surname	Kumar
Organisation	Edge Hill University
Tel (Work)	**01695 657417**
Email (Work)	**swagat.kumar@edgehill.ac.uk**
Address	Department of Computer Science Edge Hill University Ormskirk Lancashire L39 4QP United Kingdom

Role	**Head of Department**
Title	Professor
Name	Nik
Surname	Bessis
Organisation	Edge Hill University
Tel (Work)	**01695654348**
Email (Work)	**nik.bessis@edgehill.ac.uk**
Address	St Helen's Road Ormskirk ORMSKIRK Lancashire L39 4QP United Kingdom

Role	**Co-applicant 1 Head of Department**
Title	Dr
Name	Anil Kumar
Surname	E
Tel (Work)	**+91 877 2503504**
Email (Work)	**anil@iittp.ac.in**
Address	Renigunta Raod Tirupati ANDHRA PRADESH 517506 India

CO-APPLICANT DETAILS

Title	Dr
Name	Venkata Ramana
Surname	Badarla
Tel (Work)	**918772503212**
Email (Work)	**ramana@iittp.ac.in**
Address	Indian Institute of Technology Tirupati Renigunata Road Tirupati India 517506 India

Section 1 - Eligibility Criteria

Please confirm whether you meet the eligibility criteria for the International Collaboration Awards programme as follows:

Do both the lead and overseas applicants hold a salaried position at a University or not for profit organisation for the duration of the award?

? Yes

Do both the lead and overseas applicants have a minimum of 8 years active post-PhD research experience?

? Yes

Section 2 - Contact Details

COLLABORATOR DETAILS

Title	Dr
Name	Swagat
Surname	Kumar
Organisation	Edge Hill University
Tel (Work)	01695 657417
Email (Work)	swagat.kumar@edgehill.ac.uk
Address	Department of Computer Science Edge Hill University Ormskirk Lancashire L39 4QP United Kingdom

Role	**Head of Department**
Title	Professor
Name	Nik
Surname	Bessis
Organisation	Edge Hill University
Tel (Work)	01695654348
Email (Work)	nik.bessis@edgehill.ac.uk
Address	St Helen's Road Ormskirk ORMSKIRK Lancashire L39 4QP United Kingdom

Role	**Co-applicant 1 Head of Department**
Title	Dr
Name	Anil Kumar
Surname	E
Tel (Work)	+91 877 2503504
Email (Work)	anil@iittp.ac.in
Address	Renigunta Raod Tirupati ANDHRA PRADESH 517506 India

CO-APPLICANT DETAILS

Title	Dr
Name	Venkata Ramana
Surname	Badarla
Tel (Work)	918772503212
Email (Work)	ramana@iittp.ac.in
Address	Indian Institute of Technology Tirupati Renigunata Road Tirupati India 517506 India

GMS ORGANISATION

Type	Organisation
Name	Edge Hill University
Address	St Helen's Road Ormskirk ORMSKIRK Lancashire L39 4QP United Kingdom

Section 3 - Applicant Career Summary

Title of Current Position

Please state the title of your current position.

Lecturer

Current Employer

Please enter the official organisation name of your current employer.

Edge Hill University

Current Department

Department of Computer Science

Current Position Start Date

Please enter the date when your current position started.

03 June 2019

Current Position End Date

Please enter the date when your current position is expected to finish.

31 December 2050

Contract Type

Please select your current contract type from the list below.

Permanent

Field of Specialisation

Please enter details of your field(s) of specialisation.

Robotics, Computer Vision and machine learning

Summary of your Current Research

Please provide an outline summary of your present research.

Computer Vision: deep learning algorithms for depth and post estimation from monocular images, object recognition and segmentation, object detection, segmentation, and tracking,
Robotics: Hand-eye coordination, drone control, and coordination, robotic pick and place, Planning, navigation and SLAM, visual place recognition.
Embedded Systems: Raspberry Pi, Arduino, RTOS, Embedded Systems. About 7 years experience of industrial software and hardware product development experience.
The author has published about 30+ conference papers, 8 journals, 1 book, 3 white papers and several patents in these areas.

PhD Award Date

Please enter the date that you were awarded your PhD. If you have not received your PhD, please enter your expected completion date below.

03 June 2009

Applicant Career History

Please list all of your appointments since your PhD and the dates in reverse chronological order, stating if part-time (and percentage part-time) when necessary.

Edge Hill University: Ormskirk
2019-06-03 | Lecturer (Computer Science)

Tata Consultancy Services: New Delhi
2012-06-06 to 2019-06-03 | Scientist (TCS Research)

Indian Institute of Technology Jodhpur: Jodhpur
2010-05-01 to 2012-06-05 | Assistant Professor (Electrical Engineering)

Kyushu University: Fukuoka
2009-08-03 to 2010-03-31 | Academic Researcher (Computer Science)

Applicant Qualifications

Please list all your qualifications in reverse chronological order.

Indian Institute of Technology Kanpur: Kanpur
2004-07-01 to 2009-06-30 | PhD (Electrical Engineering)

Indian Institute of Technology Kanpur: Kanpur
2002-07-01 to 2004-06-30 | M. Tech. (Electrical Engineering)

North Orissa University: Baripada
1997-07-01 to 2001-06-30 | B. E. (Electrical Engineering)

Received national scholarships for PhD and Master's study at IIT.
Google Scholar h-index 12 and i10-index 16:
https://scholar.google.com/citations?user=gXORbx0AAAAJ&hl=en

List your Key and/or Relevant Publications

Journals:

(*) Event-triggered finite-time integral sliding mode controller for consensus-based formation of multirobot systems with disturbances
IEEE Transactions on Control Systems Technology
2019 | journal-article
https://drive.google.com/file/d/0B1WmoEhM2mFOd1Y5TzBhS0l3Zmc/view

(*) A Novel Vision-Based Tracking Algorithm for a Human-Following Mobile Robot
IEEE Transactions on Systems, Man, and Cybernetics: Systems
2017 | journal-article
https://drive.google.com/file/d/0B1WmoEhM2mFOUml5V1FHc1ViVm8/view?usp=drive_open

(*) High-performance loop closure detection using a bag of word pairs
Robotics and Autonomous Systems
2016 | journal-article
http://www.sciencedirect.com/science/article/pii/S0921889015300889

Kinematic control of a redundant manipulator using an inverse-forward adaptive scheme with a KSOM based hint generator
Robotics and Autonomous Systems
2010 | journal-article

On adaptive learning rate that guarantees convergence in feedforward networks
IEEE Transactions on Neural Networks
2006 | journal-article

Peer-Reviewed Conference Proceedings:

(*) "Attentive Task-Net: Self-Supervised Task-Attention Network for Imitation Learning using Video Demonstration" by Kartik Ramachandruni, Madhu Babu V, Anima Majumder, Samrat Dutta and Swagat Kumar. IEEE ICRA 2020, Paris, France May 31 - June 04, 2020.
https://drive.google.com/file/d/1Ef2dVAVOWvx0K83hD94_w5AlRLcIMY8D/view

A Reinforcement Learning Approach for Autonomous Control and Landing of a Quadrotor
2018 International Conference on Unmanned Aircraft Systems, ICUAS 2018
2018 | conference-paper

Deep Network based Automatic Annotation for Warehouse Automation
Proceedings of the International Joint Conference on Neural Networks
2018 | conference-paper

(*) Unsupervised Learning of Monocular Depth and Ego-Motion using Conditional PatchGANsInternational Joint Conference on Artificial Intelligence (IJCAI),
2019 | Conference-Paper
https://www.ijcai.org/Proceedings/2019/0787.pdf

UnDEMoN: Unsupervised Deep Network for Depth and Ego-Motion Estimation
IEEE International Conference on Intelligent Robots and Systems (IROS)
2018 | conference-paper

Autonomous leader-follower architecture of A.R. Drones in GPS constrained environments
ACM International Conference Proceeding Series
2017 | conference-paper

Designing of self-tuning PID controller for AR drone quadrotor
2017 18th International Conference on Advanced Robotics, ICAR 2017
2017 | conference-paper

Improving condition- and environment-invariant place recognition with semantic place categorization
IEEE International Conference on Intelligent Robots and Systems (IROS)
2017 | conference-paper

Managing a fleet of autonomous mobile robots (AMR) using cloud robotics platform
2017 European Conference on Mobile Robots, ECMR 2017
2017 | conference-paper

Pedestrian Detection via Mixture of CNN Experts and Thresholded Aggregated Channel Features
Proceedings of the IEEE International Conference on Computer Vision
2015 | conference-paper

Applicant Research Funding

Please list all your current and previous research funding in reverse chronological order.

2019-2020: University RIF Grant for project titled "Deep Reinforcement Learning for Hand-eye Coordination, Edge Hill University, UK, £14,000

2019-2022: Industry Co-PI for Project "Translearn" funded by Indo German Science Technology Council (IGSTC) INR 16 Million (GBP 150,000) - Collaborators: KIT, KUKA, IITK and TCS

2010-2012: PI for "Robotics for Education" funded by MHRD, Govt of India, INR 15 Million (GBP 140,000)

Section 4 - Co-applicant Career Summary

Please enter your full name, including title below.

Dr. Venkata Ramana Badarla

Title of Current Position

Please state your current position title.

Associate Professor

Current Employer

Please enter the official organisation name of your current employer.

Indian Institute of Technology Tirupati

Current Department

Please enter details of your current department name (e.g. Department of Astrophysics).

Computer Science and Engineering

Country/Territory

India

Current Position Start Date

Please enter the date when your current position started.

28 August 2017

Current Position End Date

Please enter the date when your current position is expected to finish.

31 December 2050

Contract Type

Please select your current contract type from the list below.

Permanent

Field of Specialisation

Please enter details of your field(s) of specialisation.

Wireless Networks, Cloud Computing, Internet of Things, ICT and its applications to Precision Agriculture and Smart Infrastructure

Summary of your Current Research

Please provide an outline summary of your present research.

My research activities spread equally on the core areas in computer networks and the applied fields such as Precision Agriculture and Smart Infrastructure as well. So far, I have successfully guided 4 Ph.D. and 12 Masters theses, and currently, guiding 4 Ph.D. and 4 Masters students.

A work that I had carried out and related to this project is the use of ICT techniques for efficient irrigation for agriculture. The objective was to conserve water without compromising the yeild. It involves measuring different soil parameters and take a necessary decision on applying water. Field-level experiments were conducted for over 18 months for the vegetable crops Okra and Brinjal. I would like to expand this to collect data via the multimodal sensory systems to improve the accuracy, and the cost-effective methods to scale up the solution.

* Occupancy detection methods with data fusion techniques via active/passive sensing systems, and efficient localization methods for smart infrastructures. (Ongoing, 2 Ph.D. students)

* Caching/Replacement policies, Real-time data delivery in Named Data Networks over IoT (Ongoing, 1

Ph.D. and 3 undergraduate students).

* Design and development of a generic IoT workflow builder for easy and rapid development of IoT applications (Ongoing, 3 masters students).

PhD Award Date

Please enter the date that you were awarded your PhD.

19 November 2007

Co-Applicant Career History

Please list all of your appointments since your PhD and the dates in reverse chronological order, stating if part-time (and percentage part-time) when necessary.

Associate Professor, Department of Computer Science and Engineering, IIT Tirupati from Aug 28, 2017 to till date.

Assistant Professor, Department of Computer Science and Engineering, IIT Jodhpur from Dec 28, 2010 to Aug 25, 2017.

Researcher fellow at Hamilton Institute, NUI Maynooth Ireland from May 10, 2007 to Dec 10, 2010.

Project officer in Department of Computer Science and Engineering, IIT Madras from Aug 01, 2006 to May 09, 2007.

Lecturer, School of Information and Computing, KDU College, Penang, Malaysia 2000-2002

Lecturer, Department of Computer Science and Engineering, SV College of Engineering, Chennai, India 1997-2000

Co-Applicant Qualifications

Please list all your qualifications in reverse chronological order.

Ph.D. in Computer Science and Engineering, IIT Madras, India. Thesis: Efficient Reliable Data Transport over Ad-hoc Wireless Networks: Learning Automata-based Solutions. (2002-2007)

Master of Engineering (M.E) in Systems and Information, Birla Institute of Technology & Science Pilani (BITS Pilani), India (CGPA 8.52). (1995-97)

B.Tech in Computer Science and Engineering, Nagarjuna University, India (70.00%). (1991-95)

List your Key and/or Relevant Publications

A selected list of Publications related to ICT applications for Smart Infrastructure and Precision Agriculture, and Few Interdisciplinary publications:

Journals:
Ravi Sharma and Venkataramana Badarla, “PCOC: A Fast Sensor-Device Line of Sight Detection Algorithm for Point Cloud Representations of Indoor Environments”, IEEE Communications Letters, February 2020.

Pradumn Kumar Pandey and Venkataramana Badarla, “Small-World Regular Networks for Communication”, IEEE Transactions on Circuits and Systems II: Express Briefs, September 2019.

Dipti Trivedi and Venkataramana Badarla, “Occupancy Detection Systems for Indoor Environments: A Survey of Approaches and Methods,” SAGE Journal of Indoor and Built Environment, April 2019.

Manar Amayri, Abhay Arora, Stephane Ploix, Sanghamitra Bandyopadhyay, Quoc-Dung Ngo, Venkataramana Badarla, “Estimating occupancy in heterogeneous sensor environment,” Elsevier Journal of Energy and Buildings, vol. 129, pp. 46-58, October 2016.

Heena Rathore, Venkataramana Badarla, Supratim Shit, “Consensus Aware Socio-psychological Trust Model for Wireless Sensor Networks,” ACM Transactions on Sensor Networks, vol. 12, no. 3, August 2016.

Heena Rathore, Venkataramana Badarla, K. J. George, "Socio-psychological Trust Model for Wireless Sensor Networks,'' Elsevier Journal of Network and Computer Applications, vol. 62, pp. 75–87, Feb 2016.

Douglas Leith, Peter Clifford, Venkataramana Badarla, David Malone, "WLAN Channel Selection Without Communication,'' Elsevier Computer Networks (COMNET) Journal, vol. 56, no. 4, pp. 1424-1441, 2012.

Venkataramana Badarla and C. Siva Ram Murthy, "Learning-TCP: A Stochastic Approach for Efficient Updating of TCP Congestion Window in Ad~hoc Wireless Networks,'' Elsevier Journal of Parallel and Distributed Computing (JPDC), vol. 71, no. 6, pp. 863-878, 2011.

Tianji Li, Douglas Leith, Venkataramana Badarla, and David Malone, ``Achieving End-to-end Fairness in 802.11e Based Wireless Multi-Hop Mesh Networks Without Coordination,'' ACM/Springer Journal on Mobile Networks and Applications (MONET), vol. 16, no. 1, pp. 17-34, February 2011.

Venkataramana Badarla and C. Siva Ram Murthy, "A Novel Learning Based Solution for Efficient Data Transport in Heterogeneous Wireless Networks,'' ACM/Springer Wireless Networks Journal (WINET), vol. 16, no. 6, pp. 1777-1798, August 2010.

Venkataramana Badarla, Vijay Subramaniyan, and Douglas Leith, "Low-delay Dynamic Routing Using Fountain Codes,'' IEEE communication letters, vol. 13, no. 7, pp. 552-554, July 2009.

Venkataramana Badarla, David Malone, and Douglas Leith, "Implementing TCP Flow-Level Fairness Using 802.11e in a Multi-Radio Mesh Testbed,'' IEEE communication letters, vol. 12, no. 4, pp. 262-265, April 2008.

Conferences:

Dipti Trivedi and Venkataramana Badarla, “Inferring Occupants Count from Low Power IP based Devices in Building through Data Fusion”, in proc. 13th IEEE Internation Conference on Advanced Networks and Telecommunication Systems (IEEE ANTS), December 2019.

Ravi Sharma and Venkataramana Badarla, “Analysis of a Novel Beacon Placement Strategy for 3D Localization in Indoor Spaces,” in proc. 11th International Conference on COMmunication Systems and NETworkS (COMSNETS), January 2019.

Ravi Sharma and Venkataramana Badarla, “Geometrical Optimization of A Novel Beacon Placement Strategy for 3D Indoor Localization”, IEEE ANTS workshop on Green ICT for Next Generation Wireless Networks, December 2018.

Abhay Arora, Manar Amayri, Venkataramana Badarla, Stephane Ploix, Sanghamitra Bandyopadhyay, “Occupancy Estimation Using Non-Intrusive Sensors In Energy Efficient Buildings,” in Proc. 14th International

Building Simulations Conference, pp. 1441-1448, 2015.

Ammar Adil, Venkataramana Badarla, Anand Krishnan Plappally, Ravi Bhandari and Poonam Chand Sankhla, “Development of Affordable ICT Solutions for Water Conservation in Agriculture,” in Proc. IEEE COMSNETS Workshop on Networks and Systems for Agriculture (AGRINETS), 2015.

Heena Rathore and Venkataramana Badarla, "Primary-Secondary Immune Response Adaptation for Wireless Sensor Network,'' in Proc. IEEE International Conference on Sensing, Communications and Networking (IEEE SECON), July 2014.

Heena Rathore, Venkataramana Badarla, Sushmita Jha, and Anupam Gupta, "A Novel Approach for Security in Wireless Sensor Network using Bio-Inspirations,'' in Proc. 6th IEEE International Conference on Communication Systems and Networks (COMSNETS), Jan 2014.

Venkataramana Badarla, Devesh Agrawal, and C. Siva Ram Murthy, “Design and Performance Evaluation of Meghadoot – A Hybrid Wireless Network Architecture,” in Proc. 14 th IEEE International Conference on Networks, vol. 2, pp. 1-6, Singapore, September, 2006 – won the best paper of the conference award

Co-applicant Research Funding

Please list all your current and previous research funding in reverse chronological order.

Mentor: "A Scalable Secure Architecture Model for privacy and Performance in IoT" DST-SERB, INR 20 lakhs, 2019 - Dec'22

PI “Design and Development of an Intelligent and Generic IoT based Workflow Builder”, IIT Tirupati, INR 24 lakhs, 2018 - Nov’21

Co-PI “Enabling Technologies for Intelligent Wireless Sensor Network for Health Monitoring,” Indo-Canada ISTP-GITA, INR 75 lakhs, 2014-16

PI “Design Verification and Validation of Higher Layers for up to 2 Mbps and 2-6 Mbps Waveforms,” funded by WESEE (Weapons and Electronics Systems Engineering Establishment, Ministry of Defence, Government of India), INR 9.5 lakhs, 2013-14.

PI “Efficient Water Management Systems for Precision Agriculture through ICT,” IIT Jodhpur, INR 17 lakhs, 2012-14.

Section 5 - Research Proposal

Project Title

Please give the full title of your proposed project.

iRice: Intelligent Platform for Real-time Rice Crop Monitoring and Management

Start Date

Please enter the proposed start date of the project.

01 January 2021

End Date

Please enter the proposed end date of the project.

31 December 2023

Subject Area

? Computer Engineering (incl. software)
? Control (incl. robotics)
? Agricultural Science
? Artificial Intelligence
? Machine Learning
? Vision

Abstract

Please provide a scientific summary of your proposed project. This should be a summary of your research proposal, briefly outlining the background and summarising the aims of your project.

India is one of the largest producers of most of the agricultural crops, but it ranks very low in terms of productivity. This is attributed to several factors - smaller and fragmented land holdings, lack of modern infrastructure and mechanization, movement of labor from the rural to the urban areas and the agricultural to the non-agricultural sectors, farmer's illiteracy and their unfavourable socio-economic positions. Among these, the farmer's illiteracy and their inability to access information at the right time is considered as a foremost factor affecting productivity. To address this, we propose a digital platform for on-demand information dissemination among farmers at an affordable cost, thereby, enabling them to make informed decisions and follow best practices leading to higher agricultural productivity. Particularly, we will focus on real-time and on-demand monitoring of rice crops using ground sensors and drones to detect and predict diseases and generate advisories to control and prevent them while regulating the use of pesticides and fertilizers. This is mainly because rice is one of the most important crops in India and is a main source of food and nutrition. Moreover, the household income involving rice is less than 15% in villages and the proposed data-driven platform will significantly increase this income by reducing cultivation costs and risks involved, improve the quality of rice being grown and increase overall productivity of the lands. This will not only empower villages by retaining rural labors, improving farmer's health and empowering women farmers, but also reduce environmental pollution by lowering the quantity of pesticides and fertilizers through appropriate prevention and disease management strategies. Novel research contributions will be made in three main areas: (1) Developing new algorithms for faster and accurate detection and classification of rice diseases, (2) Developing novel architectures for reducing the cost of sensor deployment and data collection from the fields, and (3) A comprehensive database of advisories, remedial actions and best practices will be created in consultation with experienced farmers and agricultural experts. A crucial aim is to demonstrate the working of the proposed system through a real-world pilot experiment involving farmers from villages in the Tirupati district of Andhra Pradesh, India. This will involve developing suitable mobile apps, websites, social media forums and setting up a call centre to manage queries and disseminate information. The research outcomes and annotated datasets will be disseminated through public engagement, publications in international conference proceedings and journals, and project websites.

Please select the primary Global Challenge Area that your research project will address from the list below:

secure and resilient food systems supported by sustainable marine resources and agriculture

Please select the secondary Global Challenge Area that your research project will address from the list below, if applicable:

reduce poverty and inequality, including gender inequalities.

Please select the primary Sustainable Development Goal that your research project will address from the list below:

Goal 3: Good health and well-being

Please select the secondary Sustainable Development Goal that your research project will address from the list below, if applicable:

Goal 15: Life on land

Lay Summary

This project aims at developing a digital platform for making information readily available and accessible to farmers in Indian villages at an affordable cost. Lack of access to expert knowledge is identified as one of the key reasons for low agricultural productivity in India as farmers don't follow best agricultural practices or find it difficult to detect crop diseases early and take necessary remedial actions in time. Crop diseases are responsible for about 10-15% of annual losses globally including India. In the absence of adequate information, farmers use pesticides and fertilizers indiscriminately, leading to higher cultivation costs and environmental and food pollution. Increased cultivation costs and risks of crop failure is considered as a leading cause of rural-to-urban migration of male labourers, leading to increased feminisation of Indian agriculture where the women are now left with the dual burden of managing household along with farm cultivation without any tangible increase in household income. The proposed data-driven platform will address the pressing need and enable the farmers to carry out real-time and on-demand monitoring of crops and seek expert guidance throughout the crop cultivation cycle at an affordable cost. Novel research contributions will be made in the area of image-based crop disease detection and prediction and, developing novel architectures for effective data collection from fields. The efficacy of the proposed platform will be demonstrated through a real-world pilot experiment involving farmers. The research outcomes and annotated datasets will be published through public engagement events, international conferences and journals and project websites.

Research Proposal

Please upload your proposal as a PDF file. PDF files must be no longer than 3 sides of A4, portrait orientation, be titled and the text size cannot be smaller than Arial size 10.

- RS-Proposal-3 Pages-v4.1
- 07/04/2020
- 12:37:26
- pdf 373.41 KB

Previous Contact

Please provide details of any previous contact with the Co-applicant and indicate whether you have met them previously.

The PI (Swagat Kumar) and Co-PI (Venkat Ramana B) were faculty members at IIT Jodhpur in India during 2010-12. SK was an assistant professor in the Department of Electrical Engineering while VB was an assistant professor in the Department of computer science. They worked together on several university-led projects such as the implementation of ICT-based education infrastructure, curriculum development for interdisciplinary centers. Since then they have been in constant touch with each other.

Multidisciplinary proposal

Please indicate whether your proposal covers more than one of the following subject groups: physical sciences; biological sciences; humanities or social science. If so, please indicate which subject groups it covers, e.g. 'My proposal covers biological sciences and social science.'

Please enter N/A if your proposal falls within one subject group only.

N/A

Outline of Data Management and Data Sharing Plan

If the proposed research will generate data that is of significant value to the research community, then please provide details of your data management and sharing plan.

As a part of this project, a dataset will be developed comprising the following information: (1) the ground sensor data (soil temperature and humidity etc.), (2) Weather data (ambient temperature, etc.), (3) Rice images showing various stages of growth and diseases, (4) expert knowledge about the treatment of rice disease, and (5) communication protocol among in situ sensors, drones, data centre, and mobile apps. This dataset will be stored in common formats such as .txt, .JPG, and .PNG, that most common languages such as C++, Java, and Python can manipulate. The data will be made available in the third year of this project through websites such as data.world, Kaggle or Github, free of use for either commercial or non-commercial purposes under one of the licenses such as Creative Commons (CC) or Open Data Commons (ODC). While these websites support long-term availability of data, a local copy will also be maintained at EHU and IITT Data servers for internal usage and sharing with other agencies on demand. Since the dataset will not include any personal information and proprietary information, there will be no restriction on the usage of data. However, we will adhere to University policy in this regard.

Overseas Field Research

Will you be conducting field research overseas?

? No

Section 6 - Use of Animals in Research

Does your proposal involve the use of animals or animal tissue?

? No

Section 7 - Use of Human Participants, Patients and Tissue

Does your proposal involve the use of human participants, patients or tissue?

? No

Section 8 - ODA Compliance

DAC Country list

? India

How is your proposal directly and primarily relevant to the development problems of these countries?

Even though India is among the largest producers of major agricultural crops, its productivity is one of the lowest in the world being at 2 tonnes per hectare which is below the world average of 2.6 tonnes/hectare. Increasing urbanization and growing population is leading to the further shrinkage of cultivable land. The problem is further exacerbated by the frequent occurrence of crop diseases and illiteracy of farmers, prevailing resource-intensive agricultural practices. Low agricultural productivity leads to low agricultural incomes, which is leading to an effect called the feminisation of Indian agriculture, arising out of increased

rural to urban migration by the male laborers. Women are now bearing the dual burden of managing farm activities in addition to managing their household chores without any tangible increase in the family income. Since agriculture provides employment to nearly 50% of the Indian population, increasing agricultural productivity (income thereof) would remarkably improve the socio-economic positions of the rural population, particularly women who now play a critical role in the agricultural economy. We believe that making expert knowledge easily available and accessible to farmers will go a long way in improving productivity of Indian agriculture while reducing environmental pollution and improving food quality.

How do you expect that the outcome of your proposed activities will promote the economic development and welfare of a country or countries on the DAC list?

The proposed data-driven digital platform will facilitate data collection, processing and information dissemination with wireless communication and minimal human intervention. This will make it easier and cheaper for farmers to monitor their crops regularly, detect the occurrence of diseases and take remedial actions in time to prevent crop failure. They will be able to seek guidance from experts at various stages of cultivation which will help them reduce cost (water, fertilizer, pesticide usage), reduce risks of crop failure due to diseases and sell their produce at competitive prices. This will, in turn, increase the productivity and profitability of agriculture, thereby increasing household income and retaining rural labours. Optimized, regulated and reduced use of pesticides and fertilizers will reduce environmental pollution and improve the quality of food being produced. The digital platform will empower the women by making information available at their fingertips. They will thus have better bargaining power and more choices to seek employment or sell their products and services without the involvement of middlemen. The overall cost of crop cultivation and management will be reduced by developing low-cost standalone ground sensor nodes that will be deployed sparsely in a given field. The data from these sensors will be collected by flying drones over the fields at regular intervals with minimal intervention. Automatic detection of diseases from images and ground sensor data will reduce the cognitive load on humans while reducing the overall cost for such tasks. Currently, the soil testing is carried out mostly in labs through the manual collection of samples. One of the objectives will be to explore the use of low-cost biosensors to automatically detect soil conditions by deploying standalone ground sensors. In short, this project will pave the way for wider adoption of precision agricultural practices among the Indian farmers leading to increased agricultural

Section 9 - Financial Details

Budget heading		2020 - 2021	2021 - 2022	2022 - 2023	Total
Consumables (inc. fieldwork)					
Consumables	Cost	£6,000.00	£6,000.00	£7,000.00	£19,000.00
Consumables (inc. fieldwork) Total	***Cost***	***£6,000.00***	***£6,000.00***	***£7,000.00***	**£19,000.00**
Travel (inc. subsistence)					
Travel	Cost	£5,000.00	£5,000.00	£5,000.00	£15,000.00
Travel (inc. subsistence) Total	***Cost***	***£5,000.00***	***£5,000.00***	***£5,000.00***	**£15,000.00**

Budget heading		2020 - 2021	2021 - 2022	2022 - 2023	Total
Equipment					
Equipment	Cost	£11,996.00	£1,061.00	£0.00	£13,057.00
Equipment Total	***Cost***	***£11,996.00***	***£1,061.00***	***£0.00***	**£13,057.00**
Research Assistant Salary					
Research Assistant Salary	Cost	£59,230.00	£59,230.00	£59,230.00	£177,690.00
Research Assistant Salary Total	***Cost***	***£59,230.00***	***£59,230.00***	***£59,230.00***	**£177,690.00**
Animal purchases					
Animal purchases	Cost	£0.00	£0.00	£0.00	£0.00
Animal purchases Total	***Cost***	***£0.00***	***£0.00***	***£0.00***	**£0.00**
Animal maintenance					
Animal maintenance	Cost	£0.00	£0.00	£0.00	£0.00
Animal maintenance Total	***Cost***	***£0.00***	***£0.00***	***£0.00***	**£0.00**
Grand Total	**Cost**	**£82,226.00**	**£71,291.00**	**£71,230.00**	**£224,747.00**

Justification for Consumables (incl. fieldwork)

Please fully justify your request for consumables, including expenses for fieldwork.

Consumables Involve the following:

- Sensors (Temp, Humidity, Soil Moisture, NPK salinity sensor), Embedded platforms (Raspberry Pi, Arduino, Beagleboards with accessories, etc.), Interfacing cards, batteries, power banks, and other electronic components (£10,000). Some of the components to be procured as follows:
Soil moisture and temperature: INR 4000 (GBP 36) x 10 = GBP 360
https://www.fabtolab.com/soil-moisture-temp-sensor
High precision soil NPK Salinity sensor: GBP 140 x 5 = GBP 700
https://www.amazon.co.uk/Neufday-Precision-Nutrient-Intelligent-Fertilizer/dp/B0836WTN59
Raspberry Pi 4 + accessories: GBP 100 x 10 = GBP 1000
https://www.amazon.co.uk/CanaKit-Raspberry-4GB-Starter-Kit/dp/B07XH3HWTQ

Arduino based kits with accessories: GBP 50 x 10 = GBP 500
https://www.amazon.co.uk/dp/B01IUZK3JO/ref=psdc_430497031_t1_B01IUY62RM
Batteries: GBP 25 x 20 = GBP 500
Zigbee/Bluetooth communication modules: GBP 45 x 10 = GBP 450
https://uk.farnell.com/digi-international/xb2b-wfwt-001/mod-xbee-2-4ghz-wifi-wire-ant/dp/2343886
Other expenses include PCB manufacturing, packaging, testing, repair etc. - GBP 2000

- Hiring ad-hoc or temporary staff (in India) to carry out fieldwork required for deploying ground sensors or weather stations in the fields. At least two persons will be employed for about 120 days over a period of 3 years to carry out these activities @ INR 1000 (£10) per day. The total cost will be 2 x 120 x £10 = £2400 for 3 years

- costs involved in conducting or organizing workshops, meetings, conferences etc. Two major workshops will be organized - one in UK and another in India. The workshop in UK will be hosted by EHU and will be used as a platform for information dissemination among students, faculty members and representatives from local industries including farming communities. The workshop in India will be used for carrying out farmer's training and awareness campaigns about the project and engaging with local bodies - agricultural universities, farming communication, local government authorities etc. About £4000 will be spent to organize these two workshops. A remaining £2600 will be used to meet other contingency expenses - paying for conference registration fees, organizing other meetings and seminars etc.

Justification for Travel (inc. subsistence)

Please provide justification for the amount requested.

Due to the strong international collaborative nature of the project, there will be research visits by the UK PI/Co-Is/RA/PhD students to partner institutions in India and vice-versa. An amount of about £15000 will be spent on supporting both domestic as well as international travel of its members. There will be 3 planned international visits (one per year) involving four persons (2 from each country) leading to a total of 12 international visits. The cost for per person per visit is @ £1000 (airfare £600, accommodation and meal £400), totaling £12000. About £3000 will be spent on arranging local conveyance for guests, supporting domestic travel within the country for fieldwork, liaison with local bodies, attending meetings, delivering seminars etc.

Out of 12 international visits, 6 visits will be used by PhD students (3 from each country) either for attending international conferences or visit partner institutes to carry out joint research with their counterparts. Remaining 6 visits will be used by PI/Co-Is/RA members of the project.

Out of £3000, about £1500 will be used by Indian partners for supporting local travels required for carrying out field surveys, meeting local authorities, organizing workshops, etc. Remaining £1500 will be used by EHU for supporting the travel of its members (PI/Co-Is/RA/students) to support outreach activities within the UK.

Justification for Equipment

Please fully justify your request for equipment.

For UK side - No Equipment will be procured by EHU

For Indian Side: (Total £ 13,057)
- One DJI P4 Multispectral Drone costing £ 6000 - necessary for carrying out R&D in UK
https://www.coptrz.com/shop/drones/dji-phantom-4-multispectral/
- Laptops and Servers for data processing: (£ 5000)

- Smartphones, storage devices, network devices, and other accessories: (£ 2057)

Justification for Salary

Please provide justification for the amount requested.

A total of GBP 177,690 will be spent on supporting people required for carrying research and development for this project. Out of which £ 55,677 will be used by the Indian side and the remaining £ 122,013 will be utilized by EHU.

For UK side:

- one Research Assistant (Grade 6) Full time - £ 113,689 for 3 years - to carry out necessary data analytic research using deep learning algorithms to detect and predict the occurrence of diseases from RGB and multi-spectral images.

- Student internships - £ 8324 for 3 years. Students will be engaged for data annotation, running and testing deep learning algorithms, mobile app development, creating websites etc.

For Indian Side:
- Two project staff for IITT for 3 years (£30,000) to carry out R&D activities related to ground sensors development, networking protocols, optimal sensor placement, mobile app development, managing websites, and a local call center. Minimum qualification: Bachelor's degree in engineering

- One project staff for ZACL for 3 years (£25,677) to focus on data collection, sensor deployment in fields, monitor and manage drone flights, liaising with farmers, etc. Minimum qualification - Master's degree in agricultural science.

Justification for Animals

Please fully justify your request for the purchase of animals and/or animal maintenance.

N/A

Financial Plan

Please provide a financial management plan for the project, including a timetable of events.

In the event of the proposal getting approved, Edge Hill University will be responsible for receiving and managing the funds received under this grant. Out of the total budget of £ 224,747, it will disburse an amount of £ 91,934 to Indian partners in three installments over 3 years. Among Indian partners, IITT will receive a budget of £ 57,000 while ZACL will receive an amount of £ 34,934 over 3 years. EHU will utilize an amount of £132,813 to support its activity over a period of 3 years.

UK Side Budget

Equipment: No equipment will be procured by EHU under this project.

Manpower:

• £ 113,689 for employing a full-time Grade 6 Research Assistant (RA) for 3 years. S/he will be responsible for carrying out necessary research and development activities primarily related to developing deep learning algorithms for detecting or predicting diseases from sensors obtained using ground sensors, weather stations and aerial images (RGB + Multispectral). The RA will also involve in delivering public

engagement and outreach activities.
• £ 8324 will be spent on Student internships over a period of 3 years during summer. The project involves a significant amount of the mechanical aspect of data collection, management, annotation and labelling, as well as supporting investigators in public engagement events, executing well-defined experiments and reporting results. We believe the best cost-effective way to carry out such activities is by employing our final year undergraduates and/or postgraduate students at a technician rate (£9.91 per hour, Grade 2 – point 10). Moreover, these students will be exposed to cutting-edge research and applications in broad areas of theoretical and experimental robotics and AI, computer vision, machine learning and data analytics applied to precision agriculture. They will also involve in supporting investigators in organizing research workshop and public engagement events. The above-mentioned activities will significantly improve their knowledge, skills and prepare them well for future career success. A total of 6 students will be recruited over 3 years. Each one will be working for 4 weeks (35 hours/week). This will be distributed over the whole duration of the project based on their availability.

Contingency / Consumables:
• EHU will use a budget of £3300 over 3 years to organize meetings, workshops, and conferences. This is essential for information dissemination among larger communities - students, faculty members and people from local industries.

• A part of this budget will be utilized to provide local hospitality to visiting delegates from Indian partner institutes invited to attend these workshops and meetings.

Travel: EHU will spend about £ 7500 over 3 years to support international travel of delegates to India required for attending meetings and workshops. It will host one meeting in the UK while supporting local conveyance for the Indian delegates. Out of this, £6000 will be used to support international travel for 6 persons to India (2 each year) @ £1000 per person per visit (airfare: £600 + accommodation and food: £600) . Remaining £1500 will be used for supporting domestic travel within the UK for its own members (PI/Co-I/RA/PhD students), visiting delegates from other institutes and local conveyance for visiting partners from India.

Indian Side Budget:
The Indian side will receive a budget of £91,934 over a period of 3 years. This budget will be managed by IIT Tirupathi and will be used for supporting activities carried out by both the partners, IITT and ZACL. This money will be spent under the following heads:

Equipment: An amount of £13,057 will be spent on equipment by IITT and ZACL. This amount will be used for buying the following main equipment:

IITT will procure the following equipment
• ONE DJI P4 Multispectral drone necessary for carrying drone-based crop monitoring activities. (£6000)
• TWO Laptops for project staff (£1000)
• One GPU Server for data processing and running deep learning algorithms (£4000)

ZACL will procure the following equipment:
• Laptop for the project staff (£700)
• Smart Phone + Portable USB storage device +communication devices + other accessories (£1357)

Manpower:
• IITT will spend about £30,000 in employing two full-time project assistants for a period of 3 years to carry out various research and development activities related to ground sensor development, developing and

testing various network architectures, managing websites, data and call centres, deploying and managing drones and ground sensors. Minimum qualification for these PA will be a Bachelor's degree in Computer Science with skills in programming, embedded system development, network communication etc.

• ZACL will spend about £ 25,677 in employing a senior agricultural researcher for a period of 3 years. He will be responsible for providing required domain knowledge in agriculture, particularly in identifying and recognizing symptoms of crop diseases and conditions and suggesting necessary remedial actions for these cases. He will also spend some time liaising with local farmers and helping them with their queries. The minimum qualification for the researchers will be a Master's degree in Agricultural science.

Travel:
The Indian side will spend a total of £7500 on supporting domestic as well as international travel of its members including Ph.D. students. It is expected that the Indian team will host one meeting in India while supporting the local travel expenses for UK delegates.

Brief Timeline of activities are as follows:

• Month 1-12, we will focus on requirement analysis, literature survey, completing WP1, WP2, and WP3 where we would develop necessary sensors nodes, network architectures, and algorithms for drone control, data transmission, processing the collected data using various data analytics algorithms. Combined with the domain knowledge from experts, necessary guidelines, notifications, warnings, and advisories will be designed and formalized.
• Month 13-18, we will focus on WP4 developing the digital platform that involves developing mobile apps, setting up call centers, websites, social media accounts and inter-linking them through our data processing center based at IITT. At least three papers will be written and submitted to international conferences. At least three papers will be written and submitted to such international conferences as International Conference on Image Processing, International Joint Conference on Artificial Intelligence, and International Conference on Agriculture and Plant Science. One workshop will be arranged in the UK (EHU) for information dissemination among students, faculty members and representatives from the local farming industry.
• Month 19-24, we will focus on WP5 carrying out a real-world pilot experiment involving farmers from local villages The activities will involve identifying farmlands and their owners to participate in this study. Sensors and drones will be deployed in their fields to collect data at regular intervals. The data thus collected will be processed and necessary advisories and guidance will be sent out to the concerned farmers through SMS/MMS/Email and other social platforms.
• Month 25-31, we will collect the feedback and improve the data collection process, algorithms for data analysis, advice provision, digital platform capability, and the user interface. A workshop will be organized in India to popularize and educate the local population about the digital platform and elicit their interest in participation.
• Month 32-36, integrate, test and deliver the developed digital platform and write the final report on the project. At least three papers will be written and submitted to such international journals as International Journal of Computer Vision, Plant Journal, and Plant Methods,
• There will be regular meetings among partners to monitor the progress of the project while collecting feedback to improve existing methods as well as system components.

** Workshops **
Workshop 1 in UK
As a part of the project, an international workshop will be organized at the British Computing Society (BCS), London. It will be a one-day symposium supported by the British Machine Vision Association (BMVA). This workshop will be targeted to researchers working in the area of AI, robotics, sensor networks, data science, machine learning and their application to agriculture technology. The train / airfare for 2 keynote speakers

and PI/Co-I/PDRA/RAs and refreshments will be around £2000.

Workshop 2 in India
To maximize the potential benefits of this research to a wider audience in India (e.g., farmers, local government representative for farming, etc.), an explicit public engagement event is planned. We plan to deliver short talks, provide interaction with our digital platform and to show videos/animations covering the science behind the proposal to generate awareness/interests, gaining knowledge about what modern technologies can achieve. This public engagement event will be delivered in Telugu (local language). The costs will include arranging travel (air/train) for invited guests, speakers, arranging refreshments for attendees and arranging printed materials for dissemination etc. The cost will be around £2000.

Section 10 - Applicant Declaration

iRice: **I**ntelligent Platform for Real-time **Rice** Crop Monitoring and Management

Collaborators: Dr. Swagat Kumar (SK), Dr. Ardhendu Behera (AB) and Prof. Yonghuai Liu (YL) from EHU, Dr. Venkat Ramana B (VB) from IIT Tirupathi and Dr. Sudhanand Bandi (SB) from Zuari Agro Chemicals Ltd (ZACL)

Importance & Research Challenges

In India, agriculture contributes about 16% of total GDP and 10% of total exports while providing employment to about 50% of the country's total workforce making it the third most important sector contributing to the national GDP[1,2]. Globally, India is ranked under the world's five largest producers of over 80% agricultural produce items and is the seventh largest agricultural exporter worldwide[3]. Over 60% of India's land is arable, making it the second largest country after the US in terms of land available for agriculture. Major challenges confronting Indian agriculture today include declining total productivity, movement of labor geographically; from the rural to the urban areas, occupationally, from the agricultural to the non-agricultural sectors, increasing participation of women in paid work, a rapidly growing demand for food (both in quantity and quality), stagnating farm incomes and unprecedented climate change[37, 3]. Among these, the lower agricultural productivity is of immediate concern for India which has attracted a considerable amount of attention in recent years. Moreover, the implementation of the Mahatma Gandhi National Rural Employment Guarantee Act (MNGEGA) and special food security programme for the below poverty line (BPL) families have contributed to the structural shifts in the work patterns and people's participation in the labor markets[37]. Rice is the lifeline for food and nutritional security for a majority of the 0.86 billion rural Indians. However, the household income involving rice is less than 15% in villages[38]. This low income is attributed to several factors such as smaller and fragmented landholdings (~1 hectare per family), lack of modern infrastructure and mechanization, low average yields, low marketable surplus, illiteracy of farmers and their unfavourable socio-economic positions (widespread rural poverty, gender pay gap, and labor migration). Rice farming involves highly labor-intensive operations and workers are withdrawing from farm activities resulting in acute shortage of labor and rising wages. Indian government's effort to popularize precision agriculture has been ineffective as the farmers neither are adequately skilled nor have adequate financial resources for implementing such systems. This project aims to develop a data-driven solution for remedial of the situation by making information easily available and accessible to farmers at any time by leveraging the advances made in the field of information communication technologies (ICT)[4,5,6] , sensor networks, and data science. Moreover, the aim is to encourage young tech-savvy rural Indians getting interested in agricultural work instead of moving out of it and rural areas. Given the limited available time, the focus will be to develop a data-driven digital platform that will facilitate real-time monitoring of rice crops. Specifically, the platform will enable to detect, manage and provide experts' advice on some of the major rice crop diseases (such as rice blast, sheath blight, sheath rot, Rice False Smut etc.) which are responsible for nearly 10-15% annual losses globally and about 20-25% in India[32,34]. The farmers will be able to seek expert guidance about preventive measures and remedial actions while minimizing the usage of pesticides and fertilizers. The existing method for crop monitoring is labor-intensive, time-consuming and requires involvement of multiple agencies making it difficult to detect or analyze diseases and receive timely feedback. The proposed digital platform aims to reduce the time involved in the entire process thereby improving the yields and profitability of rice cultivation while minimizing environmental pollution. This will, in turn, empower the village community by retaining labors, reducing gender pay-gap and improving health and wellbeing of Indian farmers, especially women who now form a significant bulk of the agricultural workforce.

Objectives: The proposal aims to achieve the following four objectives:

1. Develop a novel hybrid wireless sensor architecture to automate the process of data collection regularly from fields at an affordable cost.
2. Develop advanced data analytics methods for processing information collected from paddy fields for crop growth monitoring, disease detection, soil analysis and field management.
3. Develop and make accessible a digital platform for information dissemination among farmers and other stakeholders, as well as to motivate next generation young tech-savvy rural Indians for agriculture work.
4. Test and demonstrate the effectiveness of the above digital platform through real world pilot trials.

Research Methodology: An overview of the proposed data-driven digital platform is shown in Fig 1. The activities to be carried out under this project are grouped into the following work packages:

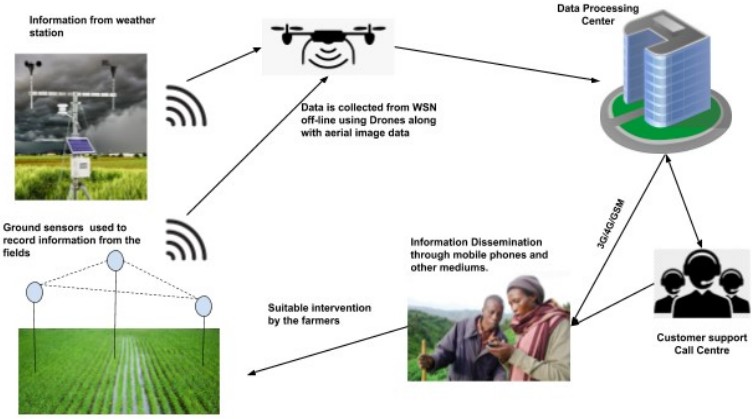


Fig 1: Components of iRice crop monitoring and management

WP1: Advanced sensing networks for environmental and farm data collection: It consists of the following sub-packages. ***WP1.1: Internet of Things (IoT) enabled common architecture for farming data collection (EHU, IITT, ZACL):*** This WP will benefit from the existing IoT and cloud computing platform for precision farming developed by the Indian partner at IIT Tirupati (RB)[22,23,24]. Existing wireless sensor architectures make use of centralized and distributed mesh networks where individual sensor nodes communicate with each other to transmit data over a long distance to a central node connected to the internet. Such architectures require closer spacing of sensors and increased battery usage (for regular transmission)[7]. We propose to explore alternate hybrid strategies, where the UAVs will be used to collect data periodically from sparsely distributed in situ ground sensors[8, 9, 10]. Since these local in situ sensors communicate only with the incoming drone and not with neighboring sensors, they could be placed very far from each other and can have longer battery life (due to reduced communication), thereby reducing the overall cost of sensor deployment. However, it would require developing suitable protocols (Such as CoAP, BNCP etc.)[21] for peer-to-peer communication between ground sensors and the UAV. This activity will be primarily led by IITT (VB).

WP1.2: UAV (drone) for crop monitoring & lighweight local stations for weather monitoring (EHU): A drone-based flight will be used to reduce the overall cost of data collection by minimizing manual visits to the fields. It will also be used for collecting several

aerial images (both RGB and multispectral) which will be used in WP2 for crop health monitoring. This work package will benefit from some of the existing algorithms for drone control and coordination developed by EHU[14,15,16,17] (SK). For weather monitoring, we will use the existing solar-powered local weather station developed in EHU[18] (AB) in collaboration with MAP of AG who were also responsible for its commercialization and use in the UK. The low-cost, lightweight and portable nature of this weather station will make it easier to deploy in the Indian farmland for accurate monitoring and prediction of fine-grained weather. The image data collected using drones will be complemented by images collected using handheld smart phones widely used by the farmers. The farmers will be able to take close up pictures of leaves and plants and send it to the data center for diagnosis and further processing.

WP1.3: Stand-alone ground sensor node development (EHU, IITT): In this work package, we will focus on developing standalone ground sensors that can measure and store information such as soil moisture, temperature and chemical composition (pesticide level)[19, 20, 33] etc. As a first step, farmlands with three areas each of about 5-10 hectares will be selected for deploying standalone ground sensors. These sensors will be packaged with suitable computing platforms or single board computers such as Raspberry Pi, Beagleboard, Arduino etc. to carry out basic tasks of collecting and storing data in a format that can be easily transferred wirelessly to a drone flying above these sensors. The UAV will make asynchronous queries to the ground sensor while flying over it and then act as a sink node to receive data from the ground sensor. This work will be led by IITT (VB) while being supported by EHU (SK). The ground sensors will get activated only when the drones are flying over it. This will reduce battery power consumption leading to longer life and lower cost of ground sensor deployment. Efforts will be made to explore the use of low-cost biosensors[33] to automate the process of on-site soil testing thereby minimizing the human effort and delay involved in manually collecting samples and getting it tested in labs.

WP2: Advanced data analytics for crop health monitoring and disease detection (EHU): The field data collected using ground sensors, weather stations and drones will be analyzed to monitor rice crop growth, detect and localize diseases in the rice crop. Particularly, we will focus on detecting various diseases in rice crops such as Rice Blast (RB)[29,30], Sheath Blight (SB)[25,31] , Sheath Rot, Rice False Smut (RFS)[27] and Rice Brown Spots (RBS)[32]. The state-of-the-art deep models (e.g. recurrent networks) will be used for analyzing time-series data obtained from ground sensors (temperature, moisture etc.) while CNN-based deep networks and saliency analysis techniques will be used to analyze images (both RGB and multispectral) collected using drones as well as ground sensors to detect these diseases[25,26,29,20]. This will benefit from the existing image processing and computer vision algorithms developed in EHU[11,12,13] (AB, PA and YL). AB and YL will focus on solving some of the challenges involved in fusing multi-modal data obtained from ground sensors, weather stations and UAVs into the deep learning pipeline to improve disease detection accuracy. Students and project staffs will be involved for labelling and annotating datasets collected in WP1 with disease and non-disease.

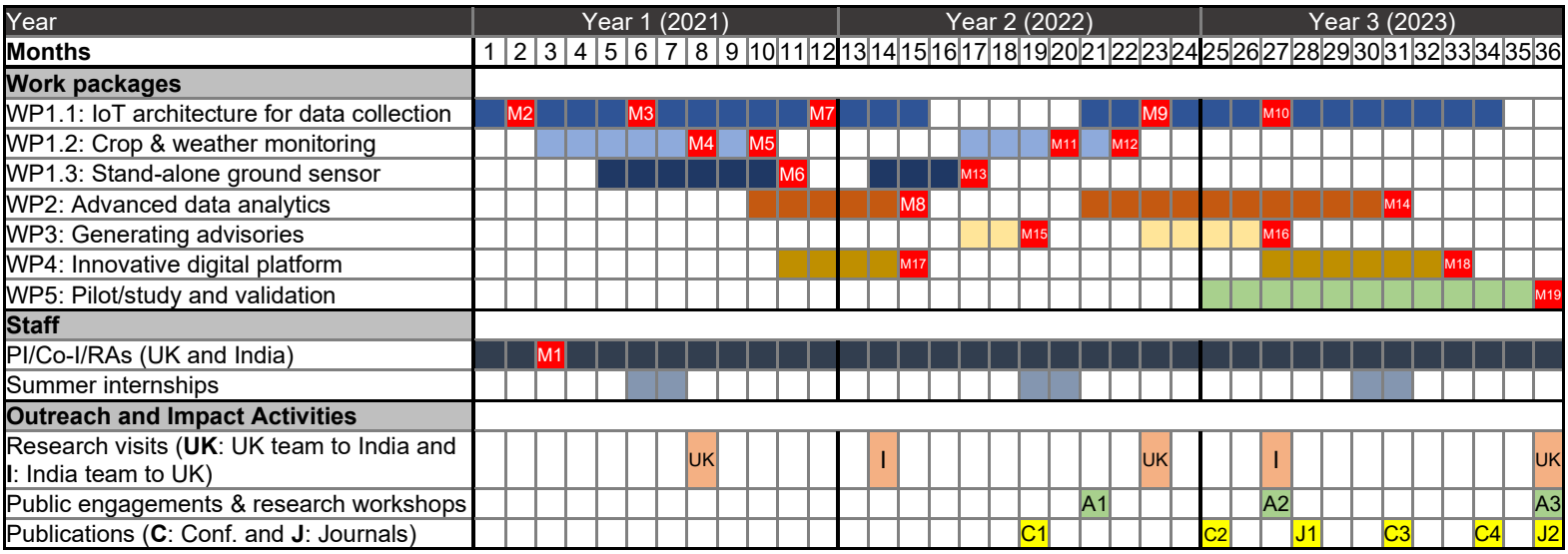
WP3: Generating advisories for disease prevention and cure (IITT, ZACL): Based on the data analytics carried out in the above sub-package, advisories will be generated to mitigate the effect and prevent future occurrence of these diseases. The advice will be considered from three aspects: cultural practices, chemical methods and biological processes. Cultural practices will comprise well-known traditional methods prevalent in a given region. Biological methods will consist of methods that use other organisms for pest or disease control. Chemical procedures will focus on best practices related to the usage of artificial fertilizers or pesticides. A database of commonly occurring diseases, their symptoms and best remedial actions will be compiled and made available for dissemination among the farmers. Guidelines on the usage of pesticides and fertilizers will be prepared based on the chemical composition of soil detected using on-ground biosensors[19,20] and local weather predictions from the data collected by the local weather stations. The guidelines and instructions will be provided in multiple languages including vernacular language (Telugu) for the benefit of local farmers. SB and other agricultural experts from ZACL will be primarily responsible for this activity since they have experiences in working closely with the local farmers. The existing knowledge database created by ZACL will be used and extended for disease management under this project.

WP4: An innovative digital platform for disseminating information to farmers (IITT, ZACL & EHU): A dedicated website and mobile app will be developed with friendly user interface for information dissemination among the farmers. The farmers will be able to make queries to our databases and experts through frequently asked questions, SMS, MMS and phone calls. They will be able to ask questions related to the diseases, their causes and severity of impact, usage of pesticides (how and when) to prevent them. They can also opt for crop monitoring service which will provide them with regular information updates related to their own fields. Under this service, warning notifications will be sent to the farmer whenever anomalies are detected in the rice crop along with necessary remedial actions to be taken to prevent further damage. This platform will allow farmers to reach out to wider communities through social media platforms such as Twitter and Facebook to discuss their issues and seek guidance at their own convenience. ZACL has already built a mobile app called 'Jai Kishan' Mobile App for engaging with the Indian farmers. Their experience will be utilized to develop a custom app for this project with several new features as mentioned above. The digital platform will be developed using open source software such as Python, MySQL, OpenJDK (Java) and operating systems such as Linux and Android.

WP5: Pilot / Study through actual field implementation, demonstration and evaluation (IITT, ZACL): The working of the above components/modules will be demonstrated through a real-life pilot experiment involving farmers from the villages in Tirupati district of Andhra Pradesh in India, identified in WP1. UAV drones will be made to fly over these ground sensors at regular intervals to facilitate data collection from these sensors. These drones will also be used for collecting aerial images (RGB + multispectral) of the crop fields during these flight missions. The collected data will be processed using algorithms developed in WP2 and WP3 to generate necessary advisories, instructions and guidance for farmers. The information gathered from experts and using the algorithms in WP2 and WP3 will be disseminated to farmers through the digital platform developed in WP4. A call centre (with a toll-free number as well as WhatsApp number) will be temporarily set up at IITT for a duration of about 6-12 months to support this activity. The data will be collected in two phases. The data collected during the first phase (Months 10-15) will be utilized for training and testing machine learning / deep learning models for disease detection and prediction. These models will then be evaluated on the data collected during the second phase (Months 21-31). The models will be fine-tuned based on this evaluation. Online feedback will be collected from the farmers to evaluate the effectiveness of the digital platform and further improve its functionalities and user

interface. A workshop will be organized to popularize the initiative and provide necessary training to farmers about the use of this platform.

Timelines and Milestones: A visual overview the project plan and linked milestones are presented below.



M: Milestones – M1: recruitment of RAs; M2: requirement analysis and literature survey; M3: IoT architecture; M4: drone control system; M5: fine-grained weather monitoring system; M6: ground sensor for soil monitoring; M7: complete sensor network for data capturing; M8: first version of data analytics module; M9: fine-tuning of the sensor network; M10: fully functional sensor network; M11: fine-tuning of drone control system; M12: refinement of fine-grained weather forecasting; M13: tuning soil monitoring sensor; M14: refinement of data analytics module; M15: inputs from experts in advisories; M16: database of advisories linking cultural practices, chemical and biological methods for crop disease preventions; M17: digital platform prototype; M18: refinement of the prototype for final deployment; M19: evaluation of the complete prototype iRice, report writing and further collaboration exploration.

A: Actions – A1: International workshop at the British Computing Society (BCS), London for PhD students, academics and researchers; A2: national workshop at EHU, targeting students, faculty members and representatives from local farming industry; A3: national workshop in India to generate awareness/interests among local farmers and government representatives for farming.

Outcomes and Deliverables

(1) Research outcomes will be published at peer-reviewed conferences and Journals. (2) Annotated datasets will be made publicly available for future research through websites such as data.world, Kaggle or Github. (3) Develop a prototype system and demonstrate its working in collaboration with local farmers. (4) Training and awareness campaign for farmers and other stakeholders.

Mutuality & Complementarity (Role of Partners)

The project will involve collaboration among three partners that include Edge Hill University (EHU) in UK IIT Tirupathi (IITT) and Zuari Agro Chemicals Limited (ZACL) in India. Their skills and expertise are complementary to each other. EHU will focus on developing advanced data analytics algorithms for analysing ground sensor data and aerial images. IITT will focus on developing new wireless sensor network architectures and stand-alone local in situ sensors. The scientists at ZACL will provide the necessary domain knowledge to generate advisories, guidance and instructions for information dissemination. The field study and pilot experiment will be conducted by ZACL in collaboration with IITT while being supported by EHU.

Dr. Swagat Kumar (SK) from EHU has intensive experience in research as well as product development in the area of robotics and autonomous control and will primarily be responsible for drone flights and their coordination. Dr. Venkat Ramana B (VB) from IITT has rich experience in teaching and research in the area of wireless sensor networks and communications and will be primarily responsible for peer-to-peer communication between ground nodes and UAVs. Prof. Yonghuai Liu (YL) from EHU has intensive research experience in the area of computer vision, image processing, remote sensing and plant phenotyping. Dr. Ardhendu Behera (AB) from EHU has varied research and teaching experience in the area of deep learning, pattern recognition and video analytics. Both will be responsible for developing data analytics algorithms required for processing ground sensor data and aerial images to detect and classify rice crop diseases. Dr. Sudhanand Bandi (SB) from ZACL has varied experience (14 years) – field research, product testing, market development and site specific plant nutrition for sustainable agriculture and soil health and will be primarily responsible for providing domain knowledge on disease manifestations and generating useful advisories on disease treatment.

Risk Analysis and Mitigation Measurements

The proposed research involves various tasks, whose executions involve some levels of risk such as delay in project execution, lack of skilled RAs for carrying out research and development, working under lockdown situations, data loss, etc. Due to the availability of the infrastructure, the existing research achievements on these tasks, and complementary expertise and experience of the team members, the levels of the risk are all either low or moderate. For the moderate level of risk for working in lockdown situations, for example, provisions will be made so that students, PI/Co-Is/RA could work from home. A cloud repository of essential services over internet will be managed to allow seamless transition. Enough protective gears for field work will be procured well in time to carry out essential outdoor activities. The risk levels will be further mitigated through effective project management such as labor division, local weekly meeting, joint monthly meeting, frequent email contact, and regular visit so that potential issues can be identified early, and mitigation measurements can be taken in due course.

References are available at this link.