Climate-KIC

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# Nitrogen Sensor for Soil Sustainability



The objective of this project is to demonstrate and implement a service for estimation and prediction of nitrogen contents so that timing and fertilization amounts are optimized for the crops – mainly focusing on cereals. Three crop species are assessed in different geographical locations using crop models, soil models, local weather inputs and weekly/monthly control of crop nitrogen status by satellite imaging.

Soil profile is important information for the modelling of plant growth and N-leaching, therefore soil samples are initially taken from three different levels.

In November 2019, Bhupjit from Technical Univesity of Denmark (DTU) was visiting one of the demonstration fields in Spain close to Madrid for installing soil sensors, a weather station, and a LoRaWAN gateway implementing wireless infrastructure. The farmer took part in the work.

**Background**

Nitrogen is an essential nutrient required for healthy growth of plants. Organic and/or inorganic fertilizers are therefore applied to the crops to maintain high yield. When fertilizers are applied to the soil, minerals start to dissolve, and inorganic nitrogen is released and absorbed by the soil.

Excessive nitrogen in the soil produces various pollutants in soil, water and air by denitrification and leaching. Denitrification is primarily caused by microbes where nitrate ($NO_3$) in the fertilizer is reduced and ultimately produces molecular nitrogen ($N_2$) through a series of intermediate gaseous nitrogen oxide products. N-leaching is a process in which the excessive fertilizer present in the soil is washed by water/rain and reaches the ground water. Therefore, denitrification and leaching produce nitrogen pollution.

In this project, advance methodologies like plant–soil modelling, precision farming, satellite image data processing, weather prediction for complete season are used to reduce excessive use of fertilizers.

Consuming groundwater or crops with high concentrations of nitrate has negative effects on human health. It is well established that the marginal uptake of nitrate drops when the optimal level of nitrogen level is exceeded.

Prediction of the optimal level of nitrogen in a heterogeneous application of fertilization addresses one of the key issues in reduction of GHG which is primary aim in modern precision agriculture. There is a strong relationship between the amount, type and timing of fertilization and the degree of N-leaching.

**Objectives**

- Reduce fertilizer usage by 20-25% which will increase farmers economic benefits
- Reduce nitrous oxide emissions and N-leaching, thus reducing global GHG emissions and local water pollution. When accurate information about current nitrogen status of the soil is at hand it is possible to have the right amount of nitrogen available at any given time. No need for uncertainty-buffer to avoid shortages. This will lead to lower washing out. It can easily mean a reduction of at least 10-15% pollution
- Enable automated post harvesting prediction of N contents in soil
- Reduce need of soil testing
- Improve field operation planning by better local weather forecasts
- Be in line with precision farming concept with generation of fertilization plan

**Nitrogen Sensor Work Package summary**

WP1: *Tuning of Nitrogen Sensor Prototype*
We work on tuning/calibration of the Daisy plant model from University of Copenhagen in order to make model reliable for the estimation of nitrogen contents in soil at the demonstration fields in Spain, Germany, Poland, Finland and Denmark. In this way Daisy becomes a virtual Nitrogen Sensor able to estimate nitrogen contents at any point in time. We also work on automating the tuning/calibration – something needing scalable computing power in cloud environment.

WP2: *Data Assimilation & Data Analysis*
In order to feed the models, e.g., Daisy plant model, with data, local weather stations and soil moisture sensors are installed at the demonstration fields. Assimilation of data is provided by means of low power, long-range wireless infrastructure. Also, soil moisture is being estimated by means of Sentinel satellite image-based algorithm developed by AgriCircle. Work includes analysis of soil samples and analysis of data, including data validation. As part hereof, FIC provides local weather forecasts based on weather data and AgriCircle provides LAI (Leave Area Index) values based on analysis of satellite images.

WP3: *Cloud Implementation*
Cloud based scalable software automation system is being designed and implemented. Models and algorithms are deployed in cloud environment and security framework is being added across the whole system to ensure authentication and trustful reliable data. Service interfaces based on REST/JSON are also designed and implemented in order to support integration with existing or future Farm Management Information Systems. Local weather forecast and nitrogen contents estimation services in precision agriculture context are provided as parts hereof. Services are made available for demonstration on website.

WP4: *Promotion website, Communication & Business models*
Project website at nitrogensensor.eu is designed and implemented for the presentation of project, including activities and results. Website contents are created during the project and connected to social medias. Commercialization plans are developed, and website is used for demonstration of developed services and for building a customer base. Late in project, a workshop will be arranged for dissemination of results. Also, scientific papers and reports will be released to the public.

WP5: *Project Management*
Management is split into technical management and resource management, which includes communication to the outside, as part hereof collaboration with other projects and 3rd parties. An initial task here is description of the overall architecture of system. Consortium has half year meetings planned to take place at the locations of the consortium partners. Work here also includes reviews of materials (papers, reports, etc.) to be released and quality assurance in general.